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THE AUTHORS OF THE SEVERAL PAPERS ARE INDIVIDUALLY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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[PROC. ROY. SOC. VICTORIA 35 (N.S.), PT. I., 1922].

ART. I.—*New or Little-known Fossils in the National Museum.*

XXVI.—SOME TERTIARY MOLLUSCA.

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(With Plates I-III.)

[Read 20th April, 1922.]

Introductory Note.

The following paper deals with fourteen new species, and also discusses points of distribution in regard to eight other forms.

A large portion of this collection has been donated to the National Museum of late years by several indefatigable collectors, to whom the authorities are much indebted. Groups other than mollusca have been equally augmented, and they will be worked out as opportunity permits.

It will be seen by the present work that even as far back as Oligocene and Miocene times there existed many species of mollusca which are so closely related to living forms as to leave no doubt that they were the direct ancestors of our present molluscan types. Others have migrated from the Bassian area, and are now only found as varietal offshoots in warmer Australian waters.

List of Species Described:—

Pelecypoda.

Pteria (Meleagrina) crassicardia, Tate sp.
Ostrea ingens, Zittel.
Neotrigonia bednalli, Verco var.
Hinnites mulderi, sp. nov.
Plicatula youngi, sp. nov.
„ dennanti, sp. nov.
„ brevispina, sp. nov.
Spondylus baileyana, sp. nov.
Modiolus mooraboolensis, sp. nov.
Lucina (Codakia) planatella, Tate.
Diplodonta harrisi, sp. nov.

Gasteropoda.

Astralium (Imperator) hudsonianum, Johnston
Turbo grangensis, Pritchard.

Xenophora (Tugarium) tatei, Harris.
Cypraea siphonata, sp. nov.
Erato obesula, sp. nov.
Murex (Muricidea) gatliffi, sp. nov.
Fusinus youngi, sp. nov.
Solutofusus curlewisensis, sp. nov.
Lyria acuticostata, Chapman.
Voluta sexuaplicata, sp. nov.
Cancellaria torquayensis, sp. nov.

Description of the Species.

Phylum MOLLUSCA.

Class PELECYPODA.

Order PRIONODESMACEA (Schizodonta).

Fam. PTERIIDAE.

Genus **Pteria,** Scopoli.

Subgenus MELEAGRINA, Lamarck.

PTERIA (MELEAGRINA) CRASSICARDIA, Tate sp.

Meleagrina crassicardia, Tate, 1886. Trans. R. Soc. S. Austr., vol. viii., p. 14, pl. ix., figs. 9, 10.

Observations.—In Dennant and Kitson's List we find the following localities mentioned for this species: Muddy Creek (lower); Lower Moorabool; and Murray River Cliffs, Oyster bed. These localities indicate respectively, Oligocene (Balcombian), Miocene (Janjukian), and Lower Pliocene (Kalimnan). The present record, from the Beaumaris Cliffs, is new for the locality, and so links on to that of the oyster beds of the Murray River Cliffs, South Australia, in point of age. This species, therefore, has a remarkably extended range. The Beaumaris specimens are the umbonal parts of very heavy shells, whilst the Balcombian examples are generally much thinner and lighter.

In the Dennant collection there is also a juvenile shell of the same species from the Muddy Creek beds (upper or Kalimnan).

Additional Occurrence.—Beaumaris Cliffs, Port Phillip. Also upper beds at Muddy Creek. Age.—Kalimnan (L. Pliocene).

Fam. OSTREIDAE.

Genus **Ostrea,** Linné.

OSTREA INGENS, Zittel. (Plate I., Figs. 1, 2.)

Ostrea ingens, Zittel, 1864, Novara Exped., Geol. Theil, vol. i., p. 54, pl. xiii., fig. 3.
Ostrea nelsoniana, Zittel, 1864. Ibid., p. 55, pl. xi., fig. 7.

Ostrea hatcheri, Ortmann, 1897. Amer. Journ. Sci., vol. iv., p. 355, pl. xi., fig. 1.

Ostrea philippi, Ortmann, 1897. Ibid., p. 356, pl. xi., fig. 2.

Ostrea patagonica, von Ihering (non d'Orbigny), 1897. Rev. Mus. Paul., vol. ii., p. 221, pl. ix., fig. 2.

Ostrea hatcheri, von Ihering, 1899. Neues Jahrb., für Min., vol. v., p. 8.

Ostrea ingens, Zittel, Ortmann, 1900. Amer. Journ. Sci., vol. x., p. 379. Ortmann, 1902, Rep. Princetown Exped., Patagonia, 1896-99, vol. iv., pt. 2, p. 99, pl. xv., xvi., xvii., xviii., xix., figs *a-c*.

Observations.—The fauna of the Miocene or Middle Tertiary beds of Victoria and South Australia contains a large form of oyster which has never been assigned to a definite species. Many examples of these large bivalves are represented in the National Museum fossil collection, but have not been specified up to the present. I am now satisfied, however, that they are identical with the New Zealand and Patagonian species, *Ostrea ingens*.

Professor Tate's useful "Census of the Older Tertiary Fauna of Australia"[1] mentions on page 249 five species of *Ostrea* from the older Tertiary (that is, Balcombian to Kalimnan), as understood by Tate. But only four are listed in Dennant and Kitson's "Catalogue of the Cainozoic Fauna," etc.,[2] so that in all probability the fifth in Tate's estimate is that now referred to *O. ingens*, Zittel.

Characters of *O. ingens*.—The chief specific distinctions given by Ortmann, and now by the writer, are:—

1. Large size and extremely thick shell.
2. Situation of muscular scar. Muscle impression large, generally situated a little below the middle of the shell, and a little posteriorly.
3. Smooth margins of the inner side of the valves, except close to the area.
4. Slight development of the radial folds. In some there is a tendency for the lamellae to develop undulae or frills, but with no marked radial disposition.

This species of *Ostrea* has been referred by H. Suter to the subgenus *Anodontostrea* (Suter),[3] the distinctive characters being the smooth inner margin. It seems, however, to belong to *Eostrea* (Ihering), for the dorsal region of the shell is often distinctly crenate.

Measurements.—Ortmann gives the length of the largest specimen as 255 mm. and the width as 162 mm.

The largest specimen in the National Museum collection appears to be an example from the Janjukian of Bairnsdale, having a length of 218 mm., and a width of 157 mm. Another specimen, from Cape Otway, also from Janjukian beds, measures 180 mm., by 135 mm.; this approaches *O. sturtiana*, Tate,[4] in its oblong shape, but is very much

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1. Journ. and Proc. Roy. Soc., N.S. Wales, vol. xxii., pt. ii., 1888, p. 240.
2. Rec. Geol. Surv. Vict., vol. i., pt. 2, 1903.
3. Descriptions of New Tertiary Mollusca, Part I. New Zealand Geol. Surv. Palaeontological Bulletin, No. 5, 1917, p. 86.
4. Trans. Roy. Soc. S. Austr., vol. viii., p. 97.

larger and heavier, and is no doubt referable to *O. ingens*. Ortmann has already drawn attention to *O. sturtiana* as being closely allied to *O. ingens*.[5] The specimen here figured is from Waurn Ponds (Janjukian), and measures 137 mm. by 112 mm.

A smaller but still heavy shell of great thickness is found in the Bailey collection from Beaumaris. It measures 120 mm. by 83 mm., and the principal lamellae number about 34. This is of Lower Pliocene age.

Distribution.—Victoria and South Australia: The Janjukian or Miocene of Bairnsdale, Cape Otway, Murray River Cliffs. Also in the Kalimnan or Lower Pliocene of Beaumaris, Port Phillip.

Elsewhere.—New Zealand: Oamaru and Pareora beds (Oligocene to Upper Miocene).

Patagonia: Upper part of Patagonian Formation and Suprapatagonian, Miocene.

Chile: Coquimbo Beds. Pliocene.

Fam. TRIGONIIDAE.

Genus **Neotrigonia**, Cossman.

NEOTRIGONIA BEDNALLI, Verco var. (Plate I., Fig. 3.)

Trigonia margaritacea, Lam., var. *bednalli*. Verco, 1907, Trans. Roy. Soc., S. Australia, vol. xxxi., p. 224, pl. xxviii., figs. 1-3.

Observations.—Dr. Verco regarded this form as a variety of the living *N. margaritacea*. From its occurrence in fossiliferous beds of Lower Pliocene age it can no longer be logically regarded as a variety of a recent type, and therefore it appears to be more consistent to give it specific rank.

This form has been taken in some abundance in the living state by Dr. Verco, who dredged it from St. Vincent's Gulf. A solitary specimen was previously found by Mr. W. T. Bednall in 1865, between the Semaphore and Glenelg.

This appears to be its first occurrence in the fossil state, and adds to the increasing list of species from the Kalimnan whose descriptions were originally based on living examples found round the Australian coast. *N. bednalli* has been dredged from 10 down to 200 fathoms. Dr. Verco's description runs as follows:—

"This variety is characterised by its very compressed shape, its narrow ribs, its large, oblong, plate-like spines, broader at their free than at their attached ends, features which are exceedingly constant in the very large series obtained."

Occurrence.—In shelly sand of Kalimnan age (Lower Pliocene), MacDonald's, Muddy Creek, near Hamilton, Victoria. Discovered and presented by Mr. James Hay Young.[6]

5. Princetown Univ. Exped., vol. iv., pt. ii., 1902, p. 105.
6. Mr. Young died on Feb. 10th, 1922. The Museum has been enriched on many occasions by his valuable discoveries.

Order PRIONODESMACEA (Isodonta).

Fam. PECTINIDAE.

Genus **Hinnites,** Defrance.

HINNITES MULDERI, sp. nov. (Plate II., Figs. 9, 10.)

Description.—Valves very inaequilateral, oblique, depressed. Anterior margin gently rounded near the umbo, truncately rounded towards the ventral, the posterior region is well-rounded, the margin sweeping forward and upward in an almost straight line to the umbonal angle made with the anterior. The neanic part of the shell is pectinoid, and feebly radiately striate, there being about sixteen fine costae. The ephebic and possibly gerontic stages show the characteristic irregularly undulose surface caused by the alternately concave and convex condition of the ventral edge; shell surface of later stages with a similarly striate and radiate ornament. Muscle impression large. Resilium small, acutely triangular.

Dimensions.—Left valve, length, 57 mm.; height, 59 mm. Height of pectinoid stage, 16.5 mm.

Observations.—The following characters distinguish this species from the allied *Hinnites corioensis*, McCoy[7]:—

1. Shell narrower or higher and more oblique.
2. Radial striae of pectinoid stage more numerous and finer.
3. Radial striae on ostreiform area not so strongly frilled by the crossing of the growth lines, the surface being sinuously striate, and not verriculate.

Occurrence.—In the white polyzoal limestone of Batesford, near Geelong. Janjukian (Miocene).

Two valves presented by the late J. F. Mulder, Esq. The species is named after its discoverer in recognition of his assiduous and successful work in bringing to light many interesting Cainozoic forms.

Fam. SPONDYLIDAE.

Genus **Plicatula,** Lamarck.

PLICATULA YOUNGI, sp. nov. (Plate I., Figs. 4, 5.)

Description.—Shell moderately thin, subtrigonal, high, oblique; left valve strongly arched. With about 20 low, rounded plaits, only conspicuous towards the ventral margin, and apparently once divided from their base near the medium area. Umbonal area rugose with irregular folds. Growth-lines more strongly marked towards the ventral border and imbricated. The pair of strong teeth in the right valve are fused to a fairly large triangular area, which is transversely striate.

Dimensions.—Height of shell (right valve), 26 mm.; length, 17 mm.; depth of valve, 7 mm.

7. Prodomus Palaeont., Dec., vi., 1879, p. 31, pl. lviii.

Observations.—The long, triangular shape of the shell reminds one of *P. australis*, Lamarck,[8] of the Philippines, but does not show the dominant sharp median ribs of that species, which extend from umbo to margin.

Occurrence.—In the Lower beds at Muddy Creek, near Hamilton, Victoria. Of Balcombian (Oligocene) age. Found by the late Mr. J. H. Young.

PLICATULA DENNANTI, sp. nov. (Plate I., Figs. 6, 7.)

Description.—Shell roundly trigonal, distinctly oblique. Right valve depressed, with more or less inflated umbo and marginal area; left valve depressed. Plicae few, about 7, bifurcating and rather acutely ridged. Teeth situated on a small, triangular hinge-plate.

Dimensions.—Right valve (cotype); height, 22 mm.; length, 18.5 mm. Left valve (cotype); height, 19 mm.; length, 15.5 mm.

Observations.—There are three examples of this species in the Dennant collection at the National Museum—two right valves and one left. A note by the late Mr. Dennant which accompanies this form says, "allied to *P. essingtonensis*." That species, however, differs from *P. dennanti* in the more numerous plicae, which are quite sharp; and in the nearly equilateral form of the shell. *P. essingtonensis*, Sowerby,[9] is a Northern Australian shell.

Occurrence.—Lower beds at Muddy Creek, near Hamilton. Dennant collection. Of Balcombian (Oligocene) age.

PLICATULA BREVISPINA, sp. nov. (Plate I., Fig. 8.)

Description.—Shell subtriangular, moderately stout, slightly oblique. With about eighteen plicae, rarely bifurcated, slightly ridged and crossed by undulating growth-lines, which develop into nodose spines at their intersection near the ventral margin. The attached umbonal area flat, from which the shell slopes away at a steep angle. Teeth attached to a short dental plate, which is obliquely striated.

Dimensions.—Height of right valve, 25 mm. Length, 22.5 mm. Depth of valve, 7 mm.

Observations.—This species differs from *P. youngi* in the rounder outline, the sharp nodose ribs, and the smaller dental plate.

It is a very ornate form compared with other species, and the fossil example is well preserved. In the style of ornament it is not unlike *P. novae-zelandiae*,[10] but that species is more depressed.

Occurrence.—Lower beds Muddy Creek, near Hamilton. Of Balcombian (Oligocene) age. Dennant Collection.

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8. Anim. sans Vert., vol. vi., p. 85. Reeve, Conch. Icon., vol. xix., 1873, pl. iii., figs. 10*a*, *c*, *d*.

Reeve, Conch. Icon., vol. xix., 1873, pl. iii., fig. 8.

10. Sowerby in Reeve, Conch. Icon., vol. xix., 1873, pl. i, fig. 1.

Fam. SPONDYLIDAE.

Genus **Spondylus**, Linné.

SPONDYLUS BAILEYANA, sp. nov. (Plate II., Fig. 11.)

Description.—Valves roundly to obliquely ovate; left valve depressed, right valve moderately convex. Shell thinner than in *S. gaederopoides*, McCoy. Hinge-line moderately long for the genus. Anterior margin of the shell widely rounded, curving obliquely to the ventral margin, and broadly rounded at the posterior angle. Surface of shell ornamented with about 6 principal radii, which are more than usually adpressed to the shell, but at intervals projecting into sharp spines, more strongly developed towards the posterior extremity. Smaller and almost obsolete radii between the stronger ones. Growth-lines faint except towards the ventral margin of full-grown specimens; never developing further than as a series of depressed lamellae. Inner surface with the margin finely toothed. Muscle impression large, situated close to the umbo.

Dimensions.—Type specimen, left valve. Length, 74 mm.; height, 82 mm.

Observations.—This species is clearly the ancestral form of the living *S. tenellus*, Reeve,[11] which is found off New South Wales and Victoria (Western Port, Phillip Island and Portland). The fossil specimen is fully twice the height, with more widely spaced radii and stronger and more adpressed spines. The Kalimnan *Spondylus spondylioloides* (or *arenicola*), Tate sp.,[12] from the Upper beds at the Murray Cliffs is distinguished by the more triangular shape and more spinous character, with obliteration of the concentric lamellae.

Occurrence.—In calcareous shelly marl, Beaumaris, Port Phillip. Collected by the late J. A. Bailey, after whom the species is named. Also in the Dennant collection, from Rose Hill, near Bairnsdale, and from McDonald's, Muddy Creek (F.C.).

Age.—Kalimnan (Lower Pliocene).

Order PRIONODESMACEA (Dysodonta).

Fam. MYTILIDAE.

Genus **Modiolus**, Lamarck.

MODIOLUS MOORABOOLENSIS, sp., nov. (Plate III., Fig. 17.)

Description.—Shell ovate, oblique, very tumid. Umbo small, incurved; a comparatively sharp umbonal ridge extending from beak to near the ventral margin, where it forms a broadly convex arch at the posterior

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11. Reeve, Conch. Icon., vol. ix., pl. xviii., fig 67.
12. Trans Roy. Soc., S. Australia, vol. viii., 1886, p. 19, pl. iv., fig. 6, as *Pecten spondylioides*. Renamed by Tate, 1896, in Rep. Australasian Association for the Advancement of Science, vol. vi., p. 318 as *Spondylus arenicola*. Although, inappropriate, this earlier trivial name must, stand, according to the rules of nomenclature.

angle. Ventral flexure or sinus well-marked, thus distinguishing it from *M. adelaidensis*, Tate, to which it bears some resemblance. The posteror margin is widely rounded, and meets the ventral margin at an obtuse angle. Surface finely wrinkled with growth striae.

Dimensions.—Height (circ.), 35 mm.; width (circ.), 29 mm.; depth of valve, 12 mm.

Observations.—This specimen from the Moorabool Valley was at first thought to be a mere variety of *M. pueblensis*, Pritchard,[13] but finding other examples in the Dennant collection from Brown's Creek, Otway, showing the same strong umbonal angulation, there is no doubt that it is distinct. *M. adelaidensis*, Tate,[14] also resembles this form in some particulars, but differs in having no conspicuous sinus on the ventral border. All the species here mentioned are confined to the Janjukian (Miocene).

Occurrence.—Type; in hard, yellow limestone, from the Moorabool River, near Maude. Geod. Surv. coll., W.T.M.4. Other specimens occur at Brown's Creek, Cape Otway (Dennant coll.).

Order TELEODESMACEA (Diogenodonta).

Fam. LUCINIDAE.

Genus **Lucina**, Bruguière.

Subgenus CODAKIA, Scopoli.

LUCINA (CODAKIA) PLANATELLA, Tate.

Lucina planatella, Tate, 1886, Trans. R.S., South Australia, vol. viii., pl. xii., fig. 11 (fig. only). Iden., 1887, ibid., vol. ix., p. 146 (description).

Observations.—This species has hitherto been recorded only from Table Cape. Its occurrence in the hard, yellow limestone of the Moorabool Valley at Maude is additional evidence in favour of the correlation of these two beds. The shell is preserved in places, showing the typical ornament.

Dimensions of the present specimen.—Height, 50 mm.; width (circ.), 48 mm. The Table Cape specimen is much smaller, measuring 33 mm. by 31 mm.

Occurrence.—Moorabool River at Maude (Geol. Surv. Vict. coll. W.T.M.4).

Age.—Janjukian (Miocene).

Fam. DIPLODONTIDAE.

Genus **Diplodonta**, Bronn.

DIPLODONTA HARRISI, sp. nov. (Plate II., Fig. 12.)

Description.—Shell moderately large, subquadrate, tumid, with well-rounded beaks, and a well-marked umbonal ridge. Anterior margin

13. Proc. R. Soc. Vict., vol. xiv., pt. i., 1901, p. 26, pl. iii., fig. 1.
14. Trans. R.S. South Australia, vol. viii., 1886, p. 123, pl. xi., fig. 3.

incurved beneath the beaks and transversely rounded to meet the nearly straight ventral margin. Posterior margin subangular, meeting the hinge-line in a straight upward slope. Surface with concentric grooves and finer striae between.

Dimensions.—Height, 28 mm.; width, 28 mm.; thickness of the two valves, 16.5 mm.

Observations.—To some extent this species resembles the commoner and more widely distributed *Diplodonta balcombensis*,[15] but the large umbones and the strong umbonal ridge, the squarer contour and the greater convexity all separate it from the other species.

I have much pleasure in naming this species after Mr. W. J. Harris, B.A., who discovered the shell.

Occurrence.—Bird Rock Cliffs, Torquay.

Age.—Janjukian (Miocene).

Class GASTEROPODA.

Order ASPIDOBRANCHIA.

Sub-order RHIPIDOGLOSSA.

Fam. TURBINIDAE.

Genus **Astralium**, Link.

Sub-genus IMPERATOR, Montfort.

ASTRALIUM (IMPERATOR) HUDSONIANUM, Johnston. (Plate II., Fig. 15.)

Imperator (*Astralium*) *imperiale* (?) Johnston, 1876. Proc. Roy. Soc., Tasmania, p. 90*c*.

Imperator hudsoniana, Johnston, 1888. Geol. Tasmania, pl. xxix., figs. 12, 12*a*.

(?)*Imperator tasmanica*, Johnston, 1888. Ibid., p. 239.

Astralium (*Imperator*), *johnstoni*, Pritchard, 1896. Proc. Roy. Soc. Vict., vol. viii. (N.S.), pp. 116-118.

Astralium (*I.*) *hudsonianum*, Johnston, sp., Chapman, 1912. Proc. Roy. Soc., Vict. vol. xxv. (N.S.), pt. i., p. 188 and footnote 2.

Observations.—The figure given by Johnston in his Geology of Tasmania, although unaccompanied by any description, renders this form a valid species. In re-naming this form as *Astralium* (*Imperator*) *johnstoni*, Dr. Pritchard gives a very full description, and adds further Victorian localities.

The specimen before us, which we have taken the opportunity to figure, is from Rose Hill, Bairnsdale. It is a large and fairly well-preserved shell, having a maximum diameter of 72 mm., with a height of 35 mm. The characters agree almost exactly with those mentioned by Pritchard. The spiral threads are often coarse and broken

15. *Diplodonta subquadrata*, Tate. Trans. R. Soc., S. Australia, vol. ix., 1887, p. 147, pl. xiv., figs. 10*a*, *b*. *D. balcombensis* (nom. mut.), Pritchard, Victorian Naturalist, 1906, vol. xxiii., p. 117.

up, becoming erect and bluntly spinose. These spiral threads on the outer, peripheral side are radiately curved, and pass into the calcarate portion of the shell.

An example from Table Cape, in the Dennant Collection, measuring 24 mm. in diameter, shows a very coarse spiral ornament on the earlier whorls of the shell.

Occurrence.—Here noted for the first time from Rose Hill, near Bairnsdale (donated by F. A. Cudmore to the National Museum). Other localities, mentioned by Dr. Pritchard are Keilor, Flemington, and the Moorabool Valley. Also found at Table Cape (Johnston, Dennant and Pritchard).

Age.—Janjukian (Miocene).

Genus **Turbo**, Linné.

TURBO GRANGENSIS, Pritchard. Plate II., Figs. 13, 14.

Turbo paucigranosa, Tate, MS. in Dennant, 1888. Trans. Roy. Soc. South Australia, vol. xi., p. 48.

Turbo hamiltonensis, Pritchard (non Harris, 1897), 1904. Proc. Roy. Soc. Vict., vol. xvii. (N.S.), pt. i., p. 329, pl. xix., fig. 4.

Turbo grangensis, Pritchard (nom, mut.), 1906. Victorian Naturalist, vol. xxiii., No. 6, p. 117.

Observations.—As the nomenclature of this species is rather involved, it may help future workers by recording the synonymy as above. In the Dennant Collection this particular species was labelled with Tate's MS. name. The most typical form there found is rather more depressed than Dr. Pritchard's type, probably owing to its being a more youthful shell. The measurements of this specimen are:— Height, 24.5 mm.; greatest diameter, 30 mm. Height of mouth, 15.5 mm. Diameter of umbilicus, 4 mm.

From the living perforated Turbos, *T. undulatus*, *Martyn* sp.,[16] and *T. stamineus*, Martyn sp.,[17] it differs both in ornament and contour, although distantly related. *T. undulatus* bears spiral ridges but they are not so pronounced, and the growth striae are not so conspicuously developed, whilst the beaded ornament is wanting. *T. stamineus* has the spiral ridges more pronounced, and the concentric growth-lines are developed as strong threads.

Occurrence.—Upper Beds at Muddy Creek and Grange Burn. Holotype from the Dennant Collection (Upper Beds, Muddy Creek). Another specimen, presented by Mr. F. P. Spry, from the Grange Burn, near Hamilton.

Kalimnan, Lower Pliocene.

16. *Limax undulatus*, Martyn, Univ. Conch, 1784, vol. i., fig. 29.
17. *Limax stamineus*, Martyn, ibid., 1784, vol. ii., fig. 71.

Order CTENOBRANCHIATA.

Sub-order PLATYPODA.

Genus **Xenophora,** Fischer.

Fam. XENOPHORIDAE.

Sub-genus TUGURIUM, Fischer.

XENOPHORA (TUGURIUM) TATEI, Harris.

Xenophora (Tugurium) tatei, Harris, 1897. Cat. Tert. Mollusca. Brit. Mus., pt. i., Australasian Tertiary Mollusca, p. 254, pl. vii. figs. 7*a*, *b*.

Xenophora tatei, Harris, Hedley, 1903. Mem. Aust. Mus., Mem. iv., pt. 6, p. 357.

Observations.—This species is very remarkable for its great persistence in time. It first appears in the Oligocene of Muddy Creek, where it is of moderate dimensions. In the Janjukian, of the Murray River Cliffs and elsewhere, it attains an enormous size. It has not been found in the Kalimnan or Werrikooian to my knowledge, but reappears in recent dredgings, as recorded by Hedley.

The Oligocene Specimens.—In the Dennant Collection at the National Museum is a fair series of specimens from the lower beds at Muddy Creek. The smallest example has a diameter of 15 mm., whilst the largest measures 45 mm. The attached fragments on the surface of the shell are chiefly polyzoa and *Siliquariae*, but the latter may be idioparasitic; that is, growing upon the adventitious fragments. Newport, Altona and Mornington are also mentioned as localities by Dennant and Kitson.[18] In the National Museum collection there are also examples from Grice's Creek, which have *Limopsis* and *Dimya* shells attached.

Janjukian Examples.—Dennant and Kitson's List[19] includes the following localities: Camperdown, Shelford, Lower Moorabool.

A fine example of *X. tatei* in the National Museum from Bird Rock Cliffs, presented by Mr. F. A. Cudmore, is almost entirely covered by fragments of bivalves. The same donor presented an enormous specimen from the Murray River Cliffs, a quarter of a mile above Morgan (lowest bed).—See wall-case, Australian Fossil Gallery, Nat. Mus. This megalomorph shows that the Janjukian fauna was at its acme of development at this phase, and dwindled down in size to the present day to the same extent as when it existed in Oligocene times. The Murray River specimen, which is a cast and mould with fragmental covering, measures 115 mm. in diameter between the extreme surfaces of the mould. The internal cast is 98 mm. in diameter. The height of the shell was approximately 70 mm. The entire shell with encrusting fragments (small oysters) measures 22 cm.

18. Rec. Geol. Surv. Vict., vol. i., pt. ii., 1903, p. 113.
19. Op. cit., p. 113.

Recent Example.—The recent record of dredged specimens from New South Wales by Hedley[20] is of great interest to the student of persistent types. The localities given are: 63-75 fathoms off Port Kembla; 54-59 fathoms off Wata Mooli; 100 fathoms, 16 miles E. of Wollongong.

Hedley states that it "corresponds with actual fossil shells from Muddy Creek, with which I have compared it." One example was 30 mm. in diameter, and apparently half-grown.

Fam. CYPRAEIDAE.

Genus **Cypraea,** Linné.

CYPRAEA SIPHONATA, sp. nov. (Plate III., Fig. 16.)

Description.—Based on cast of shell. Body whorl inflated, subglobular pyriform; spire not exsert, rather depressed. Anterior prolongation of aperture very extended, nearly as long as the body whorl, produced in a straight line in the plane of the shell base (apertural surface); posterior canal produced as in *Cypraea sphaerodoma*, Tate.

Dimensions.—Length of body whorl without prolongations, 61 mm.; width of body whorl, 61 mm.; height, 50 mm.; length of anterior prolongation, 56 mm.

Observations.—This shell, here represented by a well-preserved and complete cast, is of the type of Tate's *C. sphaerodoma.*[21] The remarkable and extensive anterior channel merits specific distinction. The longest anterior extension in *C. sphaerodoma* is, so far as I have seen, never more than one-fourth the length of the body whorl, and is always obtorted, never in a plane with the base.

Occurrence.—Tertiary (Janjukian). Below Overland Corner (left bank), and second cliff showing strata, below Waikerie, Murray River, South Australia. From the upper part of the cliff below the Kalimnan beds. Pres. and collected by Mr. F. A. Cudmore.

Genus **Erato,** Risso.

ERATO OBESULA, sp. nov. (Plate III., Fig. 18.)

Description.—Shell rather small, subrotund, spire small and depressed. Body whorl inflated. Outer lip thick, smooth, inner lip with one strong, curved plait. Aperture subcrescentic, moderately wide, canaliculate anteriorly. Surface polished, with faint folds in the line of growth.

Dimensions.—Length, 4.8 mm. Width, 4.25 mm.

Observations.—This species is by far the broadest shelled *Erato* from the Victorian Tertiaries. Its striking shape and smooth outer lip separate it from all previously described Eratos from this part

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20. Mem. Austr. Mus., Mem. iv., pt. 6, 1903, p. 357.

21. Trans. R. Soc. S. Australia, vol. xiii., 1890, p. 209. Also vol. xiii., supplement, 1892, pl. viii., fig 5.

of the world. From *E. morningtonensis*, Tate,[22] it differs in its greater width and depressed spire, whilst the outer lip is smooth, unlike that of *E. morningtonensis*, which is crenulated, and with the inner lip plaited. In its tumid form, *E. pyrulata*, Tate, approaches the present species, but differs in having a crenulated lip, and more exsert spire.

Occurrence.—In the blue clay of Balcombe Bay, Mornington. Found and presented by Mr. J. H. Gatliff. Balcombian (Oligocene).

Fam. MURICIDAE.

Genus **Murex**, Linné.

Sub-genus MURICIDEA, Swainson.

MUREX (MURICIDEA) GATLIFFI, sp. nov. (Plate III., Fig. 19.)

Description.—Shell of medium size, turrited, and with a short canal. Spire elevated, apical angle 36°, longer than the body whorl, consisting of six turns besides the protoconch. Suture deeply impressed, whorls rounded, subangulate below the middle, with costate varices often becoming lamellose or scaly, about 10 on body whorl. Costae crossed by fine rounded spiral threads, about 10 on the penultimate whorl, and 26 on the body whorl with even finer intermediate ones; one on the angulation much thicker and prominent. The entire surface crossed with fine varicial lines passing over the spiral and coarser threads. Aperture roundly pyriform, with a nearly straight canal. Inner lip having a thin callus and a single columellar fold about midway in the aperture; outer lip thin, smooth. Protoconch small, consisting of one and a half turns, the initial portion obtuse.

Dimensions.—Height, 26 mm.; length of body whorl, to end of canal, 16 mm.; width of body whorl, 14 mm.; greatest width of aperture from inner lip, 7 mm.

Observations.—The above species is not unlike some living Trophons in general outline,[24] but the tendency to form lamellose varices and its decided affinity both to *Murex asperulus*, Tate,[25] and *M. camplytropis*, Tate,[26] makes its generic position clear. From both the forms mentioned, *M. gatliffi* differs in the greater number of costae and in the shape of the protoconch; whilst *M. asperulus* has a larger and more twisted canal and less extended spire. *M. camplytropis* differs in having a heavier shell, denticulate outer lip and pseudo-umbilicus.

Occurrence.—In the blue clay of Balcombe Bay, Mornington. Bal-

22. Ibid., vol xiii., 1890, p. 217.
23. Ibid., vol. xiii., p. 216, pl. xiii., fig. 12.
24. In making comparisons with living genera and species, I have been materially assisted by Mr. C. J. Gabriel, to whom by best thanks are due.
25. Trans. R. Soc. S. Australia, vol. x., 1888, p. 106, pl. iii., fig. 1.
26. Ibid., p. 105, pl.iii., fig. 2.

combian (Oligocene). Collected and presented by Mr. J. H. Gatliff; named in recognition of his valuable work in Victorian conchology.

Fam. FUSIDAE.

Genus **Fusinus**, Rafinesque.

FUSINUS YOUNGI, sp. nov. (Plate III., Fig. 20.)

Description.—Shell long, fusiform. Spire turrited; apical angle 17°. Protoconch smooth, globular at apex, of two turns. Whorls angulate, upper and lower faces flat or slightly concave; shoulders carinate, with about 10 sharp almost spinose and flattened tubercles on each whorl. Ornamented with numerous, closely set, spiral lirae, interrupted on the siphonate part of the body whorl. Lirae crossed by numerous fine vertical threads, forming a delicate mesh-ornament. Aperture narrowly ovate. Canal long, inner lip smooth, outer thin.

Dimensions.—Length, 27 mm; greatest width of body whorl, 7 mm.; length of spire, above body whorl, 12.5 mm.; width of aperture, 2 mm.

Observations.—The original specimen (holotype) was found at Curlewis, and in the Dennant Collection there is a specimen from the same locality, and also others from Shelford and Belmont not quite so elevated in the spire, but clearly referable to the same species. There is no other form quite related to this in the Victorian Tertiaries. From the New Zealand Tertiary, Suter has described[27] a *Fusinus* (*F. climacotus*) from the Oamaru Series of Enfield, which approaches the above species, but differs in the more numerous shoulder tubercles and coarser vertical growth-lines.

Occurrence.—Janjukian (Miocene), Curlewis. Collected and presented by the late Mr. J. Hay Young of Meredith. Also found at Belmont, Curlewis and Shelford by J. Dennant (Dennant coll.).

Genus **Solutofusus**, Pritchard.

SOLUTOFUSUS CURLEWISENSIS, sp. nov. (Plate III., Fig. 21.)

Description.—Shell turrited, very attenuate. Whorls convex, slightly fluted vertically. Sutures deeply incised or canaliculate, partially separating the whorls. Aperture elongate, pyriform, with a long, slightly twisted canal, rather less than one third the length of the shell; inner lip thinly callused, outer lip fairly thick and transversely costate on the inside. Ornament of sharp lirae, with grooved interspaces, and a median thread; crossed by numerous vertical threads. Protoconch finely scaly, cylindrical, apically flattened of two and a half whorls. Neanic stage of shell with nearly obsolete costae, later whorls becoming evenly convex.

Dimensions.—Length, 56 mm.; width of body whorl, 13 mm.; height of protoconch, 2.5 mm.

27. Palaeontological Bulletin, No. 5, New Zealand Geological Survey, 1917, p. 21, pl. iii., fig. 12.

Observations.—The separation of the whorls in this species is not so pronounced as in the genotype, *Solutofusus carinatus*, Pritchard,[28] but this character is too decided in the present form for its inclusion in *Fusinus* (formerly *Fusus*, pars). The slightly tuberculate costae of the earlier stage of the shell is suggestive of Tate's *Fusus hexagonalis*,[29] but the rounded later whorls and their canaliculation easily separates the two forms. It is worth noting that *Solutofusus carinatus* and *Fusus* (*Fusinus*) *hexagonalis*, Tate, agree in having an exsert protoconch, whilst the present species has the apex flattened; so that that feature does not seem to be constant in *Solutofusus*.

Occurrence.—Janjukian (Miocene). Curlewis, near Geelong. Collected and presented by the late Mr. J. H. Young. There is a related specimen with ornament closer to *Fusinus hexagonalis*, but with canaliculate sutures, in the Dennant collection, from Shelford.

Fam. VOLUTIDAE.

Genus **Lyria**, Gray.

LYRIA ACUTICOSTATA, Chapman. (Plate III., Figs. 22, 23.)

Lyria acuticostata, Chapman, 1920. Proc. Roy. Soc. Vict., vol. xxxii. (N.S.), pt. ii., p. 241.

Observations.—Since the above-mentioned description was written, I have been able to identify some smaller and rather rare shells of the genus from the Balcombian, with the larger and better developed Miocene forms. These smaller forms have all the essential characters of the Ooldea and Torquay fossils, but are thinner in build, though otherwise typical; they are therefore included here under the same trivial name, and may be regarded as ancestral and deep water forms (of Balcombian age), of the Ooldea shells (of the Janjukian).

Dimensions.—Length of a full-grown Balcombian shell (from Balcombe Bay), 23 mm. Length of a shell from Torquay, 42 mm. Length of a Janjukian shell from Ooldea, circ. 60 mm.

Occurrence.—Balcombian (Oligocene). Balcombe Bay and Grice's Creek, Port Phillip. Janjukian (Miocene), Bird Rock Cliffs, Torquay, Victoria; and Ooldea, South Austrilia.

Genus **Voluta**, Linné.

Sub-genus AULICA, Gray.

VOLUTA (AULICA) SEXUAPLICATA, sp. nov. (Plate III., Fig. 24.)

Description.—Shell long-ovate with hemispherical protoconch of two and a half turns, moderately large and turbinoid. Apical angle of shell 33°; consisting of four depressed convex whorls, with im-

28. Proc. Roy. Soc. Vict., vol. xi., pt. i., 1898, p. 102, pl. vii. figs. 1, 1*a*, 2.
29. Trans. Roy. Soc. S. Australia. vol. x., 1888, p. 139, pl. iii., figs. 15*a*, *b*.

pressed sutures. Outer lip not so extensive as in *V. ellipsoidea*, with a straight margin rather than convex; inner lip with a thin callus and six plaits, of which the anterior is oblique, and just within the entrance to the canal, the second, third and fourth slightly oblique and evenly spaced, the fifth and sixth smaller and close together beyond the second third of the inner lip margin. Surface nearly smooth, covered with fine indistinct striae, both spiral and vertical.

Dimensions.—Length, 72 mm. (body whorl, 46 mm.; spire, 26 mm.). Width of body whorl, 23.5 mm. Height of protoconch, 4 mm.

Relationships.—The nearest species to which the above form is related is *V. ellipsoidea*, Tate.[30] It differs, however, in the depressed convexity of the whorls, the compression of the outer lip, the narrower protoconch, the more oblique sutures, and the absence of lirae. Besides these differences, *V. sexuaplicata* has the two extra plicae on the inner columellar lip.

Occurence.—*Voluta (Aulica) sexuaplicata* is represented by a well-preserved example from the Balcombian (Oligocene) of Clifton Bank, Muddy Creek, presented by Mr. G. P. Tait.

Fam. CANCELLARIIDAE.

Genus **Cancellaria**, Lamarck.

CANCELLARIA TORQUAYENSIS, sp. nov. (Plate III., Fig. 25.)

Description.—Shell bucciniform, stout, with a small rounded protoconch of two turns, and five moderately convex whorls. The ephebic and neanic stages have rather flattened whorls, ornamented with well marked spiral striae, vertically lineated. Penultimate and body whorl inflated, with about 15 rounded costae; both these and the interspaces transversely grooved with deeply incised lines.

Dimensions.—Height, 23 mm.; width of body whorl, 15 mm.; height of body whorl, 14.5 mm.

Observations.—This shell is of the type of *Cancellaria australis*[31] in the costate and spirally grooved ornament. The spire in *C. torquayensis* is more elongated and the costation is not seen until the fourth whorl.

Occurrence.—Janjukian (Miocene). Bird Rock Cliffs, Torquay. Collected and presented by Mr. F. A. Cudmore.

CORRIGENDA.

New or Little-known Victorian Fossils, part xxv., Proc. Roy. Soc. Vict., vol. xxiii. (N.S.), 1921.

P. 224, eighth line from the bottom—for "*Aveolites*" read "*Alveolites*."

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30. Trans. Roy. Soc. S. Australia, vol. x., 1888, p. 176, pl. xiii., fig. 4; and vol. xi., 1889, p. 127.

31. *Cancellaria australis*, Sowerby. Conch. Illustr., 1841, fig. 23. Thesaurus Conch., vol. ii., p. 442, pl. xcv., figs. 72, 73.

Also plate ix. title—for "Michelina" read "Michelinia."
Plate x. title—for "Michelina," read "Michelinia," and for "Romingera," read "Romingeria."

EXPLANATION OF PLATES.

Plate I.

Fig. 1.—*Ostrea ingens*, Zittel. Interior of left or lower valve. Miocene (Janjukian), Waurn Ponds, Geelong, Mulder coll., circ. two-thirds natural size.

,, 2.—*O. ingens*, Zittel. Exterior of same specimen. Circ. two-thirds natural size.

,, 3.—*Neotrigonia bednalli*, Verco var. Left valve. Lower Pliocene (Kalimnan). Macdonald's, Muddy Creek, Pres. J. H. Young. Slightly enlarged.

,, 4.—*Plicatula youngi*, sp. nov. Exterior of right valve. Oligocene (Balcombian). Clifton Bank, Muddy Creek. Coll. J. H. Young. Slightly enlarged.

,, 5.—*P. youngi*, sp. nov. Interior of right valve of same specimen. Slightly enlarged.

,, 6.—*Plicatula dennanti*, sp. nov. Exterior of right valve. Oligocene (Balcombian), Lower Beds, Muddy Creek. Coll. by J. Dennant. Slightly enlarged.

,, 7.—*P. dennanti*, sp. nov. Interior of a left valve. Oligocene (Balcombian), Lower Beds, Muddy Creek. Coll. J. Dennant. Slightly enlarged.

,, 8.—*Plicatula brevispina*, sp. nov. Exterior of right valve, Oligocene (Balcombian), Lower Beds, Muddy Creek. Coll. J. Dennant. Slightly enlarged.

Plate II.

Fig. 9.—*Hinnites mulderi*, sp. nov. Left valve. Miocene (Janjukian). Batesford, near Geelong. Pres. J. F. Mulder. Nat. size.

,, 10.—*H. mulderi*, sp. nov. Interior of left valve of same specimen. Nat. size.

,, 11.—*Spondylus baileyana*, sp. nov. Left valve. Lower Pliocene (Kalimnan), Beaumaris, Port Phillip. J. F. Bailley coll. Nine-elevenths nat. size.

,, 12.—*Diplodonta harrisi*, sp. nov. Left valve. Miocene (Janjukian), Torquay, near Geelong. Pres. by W. J. Harris. Nat. size.

,, 13.—*Turbo grangensis*, Pritchard. Umbilical aspect. Lower Pliocene (Kalimnan). Grange Burn, near Hamilton. Dennant coll. Slightly enlarged.

,, 14.—*T. grangensis*, Pritchard. Same specimen, lateral view. Dennant coll. Slightly enlarged.

,, 15.—*Astralium (Imperator) hudsonianum*, Johnston. Miocene (Janjukian). Rose Hill, near Bairnsdale. Pres. F. A. Cudmore. Slightly enlarged.

PLATE III.

Fig. 16.—*Cypraea siphonata*, sp. nov. Cast of shell in matrix. Miocene (Janjukian). Murray River Cliffs, South Australia. Presented by F. A. Cudmore. Circ. nine-tenths nat. size.

„ 17.—*Modiolus mooraboolensis*, sp. nov. Right valve. Miocene (Janjukian), Moorabool River, near Maude. Coll. Geol. Surv. Vict. Five-eighths nat. size.

„ 18.—*Erato obesula*, sp. nov. Oligocene (Balcombian). Balcombe Bay, Port Phillip. Pres. by J. H. Gatliff. Enlarged slightly more than four-thirds.

„ 19.—*Murex (Muricidea) gatliffi*, sp. nov. Oligocene (Balcombian), Balcombe Bay. Pres. J. H. Gatliff. Slightly enlarged.

„ 20.—*Fusinus youngi*, sp. nov. Miocene (Janjukian). Curlewis, near Geelong. Pres. J. H. Young. Enlarged nearly twice nat. size.

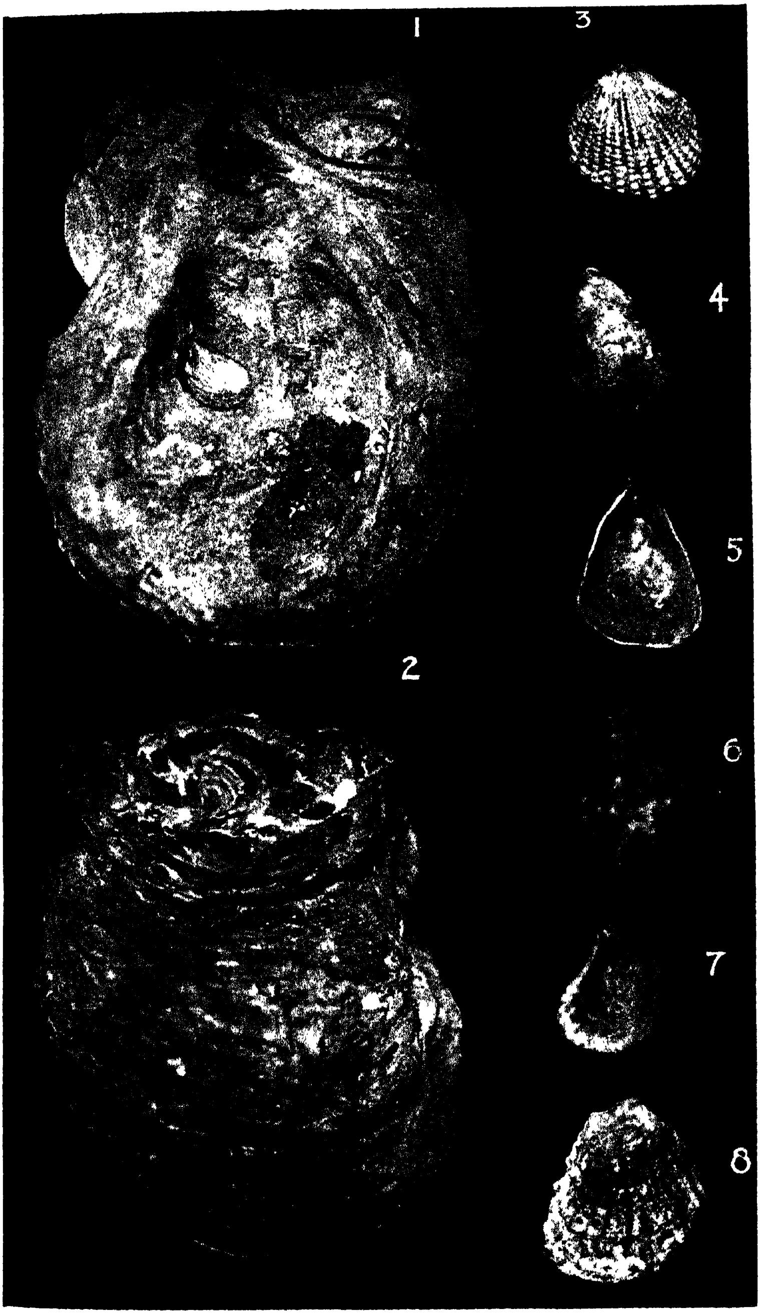
„ 21.—*Solutofusus curlewisensis*, sp. nov. Miocene (Janjukian). Curlewis. Pres. J. H. Young. Enlarged seven-sixths nat. size.

„ 22.—*Lyria acuticostata*, Chapman. Megamorphic example. Miocene (Janjukian). Torquay, near Geelong. Dennant coll. Nat. size.

„ 23.—*L. acuticostata*, Chapman. Micromorphic example. Oligocene (Balcombian). Balcombe Bay. Nat. size.

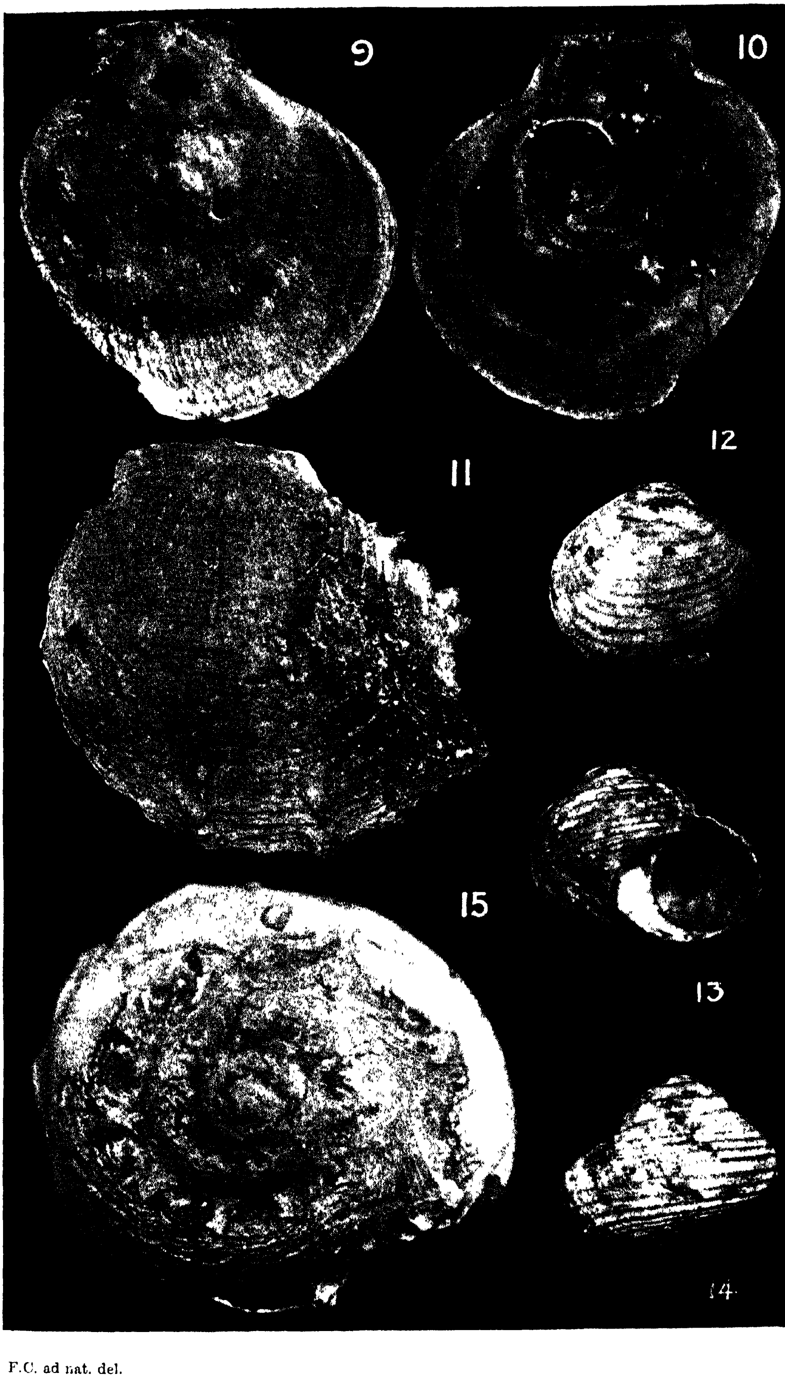
„ 24.—*Voluta sexuaplicata*, sp. nov. Oligocene (Balcombian). Clifton Bank, Muddy Creek. Pres. G. P. Tait. Nat. size.

„ 25.—*Cancellaria torquayensis*, sp. nov. Miocene (Janjukian). Bird Rock Cliffs, Torquay. Pres. F. A. Cudmore. Slightly enlarged.



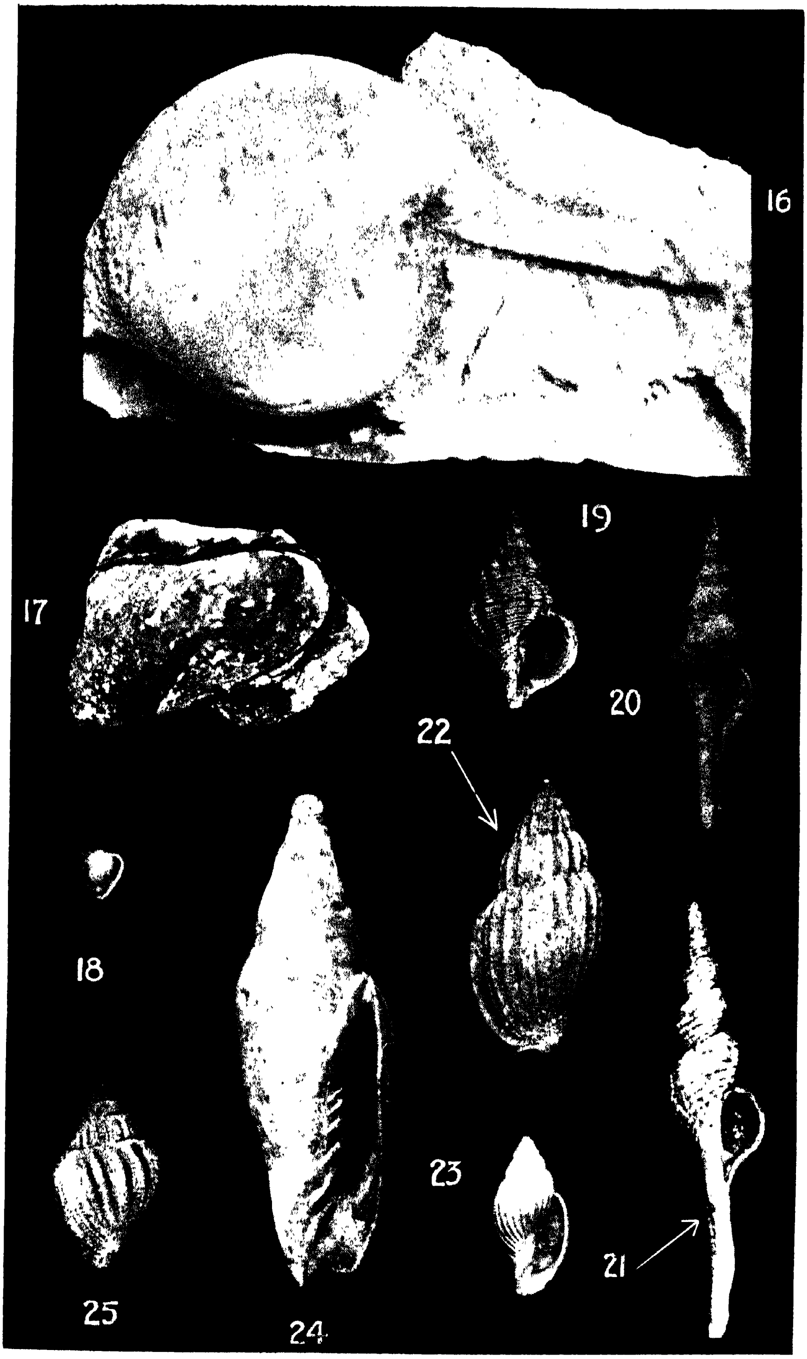
F.C. ad nat. del

Ostrea, Neotrigonia, Plicatula: Tertiary.



F.C. ad nat. del.

Hinnites, Spondylus, Diplodonta, Astralium, Turbo: Tertiary.



F.C. ad nat. del.

Cypræa, Modiolus, Erato, Murex, Fusinus, Solutofusus, Lyria, Voluta, Cancellaria: Tertiary.

PROC. ROY. SOC. VICTORIA 35 (N.S.), PT. I., 1922.]

ART. II.—*On Coprosma Baueri, Endlicher.*

By JOHN SHIRLEY, D.Sc., and C. A. LAMBERT.

(With Plate IV.)

[*Read 20th April, 1922.*]

1. The Genus.

Coprosma is a genus of Rubiaceæ, comprising some 60 species, whose headquarters are in New Zealand. The Dominion and its dependencies possess 39 of these species(1), Australia five(2), and the remaining units extend northward to New Guinea and Borneo, and westward to the Sandwich Islands and Juan Fernandez, near the Pacific coast of South America. The New Zealand species form dense thickets, both in lowland forests and in woods to heights of 6000 feet. They vary very much in mode of growth and foliage at different periods of their life history. Many Coprosmas have the aspect of desert plants, as have also New Zealand species of *Pennantia*, *Hoheria* and *Plagianthus*, and are consequently termed xerophytes. These show great range of variability in their leaves; the seedling and mature stages possessing larger leaves than the intermediate one. This xerophytic habit, so strongly represented in the flora of a temperate, well watered group of islands, has been a fertile source of discussion by biologists and geologists. Hutton(3) asserts that during the Pliocene period the Southern Alps were much higher than now, and that such groups as the Chatham and Auckland Islands were part of the New Zealand mainland. The plains east of the main ridge were arid and wind-swept, with warm summers, and very cold winters. Dr. L. Cockayne(4) explains that the seedling stage of these plants of xerophytic aspect, and with an alternation of leaf forms, represents the ancestral plant before the Pliocene desiccation; the intermediate foliage represents the plant of Pliocene New Zealand; and the larger leaves of the mature form are the response to present conditions. Two erect species with large coriaceous shining leaves are commonly cultivated in public and private gardens throughout Australia—*C. Baueri*, Endl., and *C. lucida*, Forst.

2. Previous workers.

Cheeseman(5), in an article on "New Zealand Species of Coprosma," refers to the curious little pits that exist on the under surface of the leaves of these plants, states that they are often inhabited by a tiny yellow acarid, but confesses that he is unable to guess as to their function.

Dr. A. N. Lundström (6) applied to the pits the name domatia, and decided that they were of use to the plant as the home of commensals, living in symbiosis with it. Mr. Alexander Hamilton(7)

1 The numbers refer to works consulted, shown in the Bibliography at the end of the paper

gave a general review of these curious leaf organs, dealing especially with the histology of the leaf of *Pennantia Cunninghamii*, Miers, and figuring a hair from the pit of *Coprosma lucida*, Forst. Both of these writers (6, 7) lay much stress on the use of the pits as a habitation for Acarina, though Hamilton acknowledges that as often as not the pits were found without guests. Where mites were numerous he found the walls of the cavities damaged, showing brownish patches and bright crimson cells. It is remarkable that the kaikomako or New Zealand Pennantia is in its young state a shrub, whose flexuous interlacing branches and small distant sessile leaves give it the aspect of a xerophyte; while in its mature stage it is a tree, 20 to 30 feet high, with stalked glossy leaves two inches in length. A very important paper on the Coprosma leaf pits is that by Miss N. A. R. Greensill (8), dealing with the minute structure of the leaves of ten New Zealand species, and reviewing all work on the subject to date. Miss Greensill utterly failed to find insect guests in the so-called *domatia*, either in species cultivated in gardens and public parks, or in those growing under natural conditions; she found some pits in an unhealthy state with brown patches and crimson-coloured cells, but traced these changes to attacks of fungi. Miss Greensill favours the view that the pits absorb moisture. Mr. Nathan Banks (9) figures three structures in leaves caused by Acarina, which he terms dimple gall, capsule gall, and pouch gall respectively, caused by mites *Eriophyes pyri*. The pear-leaf blister mite is found in Australia.

3. Histology.

I. Leaf Structure of C. Baueri

The pits lie on each side of the midvein, at junctions with primary veins, and vary in number from four to nine; those in the lower part of the leaf are often immature and closed, when the upper ones are mature and open. Very rarely are they found on the primary veins; and in each case noted this abnormal position was limited to a single pit. In transverse section, (fig. 1), the leaf shows an upper epidermis of three layers. The first is constructed of small ovate cells, with their longitudinal axis parallel to the surface, irregular in size, the longest about 31 μ. This layer is clothed externally by cutin measuring one-half to one-third the transverse diameter of a cell. The units of the second layer show no cell contents, and are polygonal in outline; their greatest diameter is 65 μ. The third layer is composed of cells (fig. 2) showing transition forms between those of the second layer and palisade cells, the shape is rhomboidal or rhombo-polygonal, and the long axis is at right angles to the surface, the greatest length is 33 μ. Palisade cells proper are in three rows, slender in outline, 54 long, three or four abutting on each pair of third rank epidermal cells. The spongy parenchyma (fig. 1), shows cells of various outlines—oval, globular, dumb-bell shaped, etc., seldom exceeding 35 μ in diameter. The intercellular spaces between them are very small; with the exception of those near a pit they communicate by numerous small stomata.

with the outer air. Stomata are of usual type, surrounded by the ordinary epidermal cells, which have not the wavy outline common to their class. The lower epidermis is of a single layer of minute rounded-oval cells, raised into short bluntly conical points on their free surfaces (fig. 3). Numerous unicellular hairs coat this lower leaf surface, most of which spring from an inflated base (fig. 3), and sometimes from a pear-shaped cell, larger than the epidermal cells among which it is inserted.

II The Leaf Pits. (Fig. 1).

In transverse section the pits present various irregular shapes, and widen rapidly from their openings. In common with other portions of the lower epidermis, these pits are beset with numerous unicellular nucleated and non-nucleated hairs. Each pit is lined with epidermal cells, clothed outwardly with cutin, and set with the longitudinal axis at right angles to the surface. Though the spaces in the spongy parenchyma may only be separated from the outer air by two layers of cells, no stomata have been found in these depressions.

III. The Veins. (Fig. 1.)

In transverse section the midrib presents an upper epidermis of a single layer of cells, resembling those of the outer layer in the blade. Beneath this is a mass of cortical cells, most thickly developed on the lower surface, and enclosing a vascular bundle, of which the xylem elements form the upper, and the phloem elements the lower, portion of the bundle, as is usual in dicotyledonous leaves. A well marked pericycle surrounds the whole, its cells blending into the mass of cortical cells on the upper margin. In smaller veins the bundle sheath is formed of large cells, whose outer walls are considerably thickened, and when the vein is cut at right angles the sheath resembles a minute necklace. The vessels of the xylem are mainly spirally strengthened, and those of the protoxylem are exceedingly slender and delicate.

IV. The Stem. (Figs. 5 and 6.)

In transverse section, fig. 5, the stem is peculiar for the depth of the bast layer, and for the way in which it gradually merges into the phelloderm of the cortex. The only difference in transverse section between phloem and phelloderm is the direction of the longitudinal axis in their cells, in the former running radially, in the latter circumferentially. The phellogen shows clearly, and there is a layer of empty cells below the dead cork.

In longitudinal section, (fig. 6), the elements of bast and wood are particularly interesting, especially in reference to the xylem and phloem parenchyma, which are very well represented. The wood parenchyma is exactly of the type illustrated by Strasburger(11), as are also the tracheides, with narrow oblique bordered pits, figured by that author under the term *fibre tracheides*. In tangential section the medullary rays

are three to four cells thick, the elements unequal in size, and arranged in oblique series. The cells are evidently of two types, the outer ones showing circular bordered pits, which in the inner cells are absent.

4. The Functions of the Pits.

My colleague, C.A.L., examined a large number of leaves in Melbourne gardens, and in no case found insect guests inhabiting the pits; an examination of plants in the Sydney Botanic Gardens in January, 1921, and in the Brisbane Botanic Gardens in October, 1921, also gave negative results. Miss Greensill reports similarly of her experience of New Zealand species of Coprosma. This seems to dispose of Lundstrom's theory that the pits are the homes of commensals. To test whether these pores are sources of a supply of moisture to the leaf, similar to those figured by Kerner and Oliver(12) the pits on healthy leaves, still attached to the plant, were filled by C.A.L. with a quickly drying varnish, and flourished as well as ever, proving that absorption through the pores is no necessary function. It has already been stated that the pits do not contain stomata, and that these organs are minute in size, and numerously spread over the surface of the lower epidermis. After exhausting the aids of the microscope and of experiment, our conclusion is that the pores were formerly of assistance to the plant when under xerophytic conditions, and that in the Miocene age of continental New Zealand, the stomata were confined to them, as in the leaves of many of our Hakeas, but that with modern and more humid conditions, the leaves have developed stomata on their lower epidermis, and the pits are now useless to the plant, having only an interest to the teleologist.

EXPLANATION OF PLATE IV.

Fig. 1—Transverse section of leaf.
  e. Pit.
  f. Midrib.
Fig. 2—a. Epidermis and cutin.
  b. Epidermal cells of second layer.
  c. Palisade cells.
Fig. 3—Epidermis, underside of leaf.
Fig. 4—Upper epidermis, surface.
Fig. 5—Transverse section of young twig.
Fig. 6—Tangential section.
  a. Medullary rays.
  b. Fibre tracheids.
  c. Trachea.
Fig. 7—Basal membrane of pit.
Fig. 8—Nucleated hair from base of pit.

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1. Cheeseman, T. F.—Manual of the New Zealand Flora, 1906, p. 243.
2. Bentham—Flora Australiensis, Vol. III., pp. 429-30.

Fig. I.

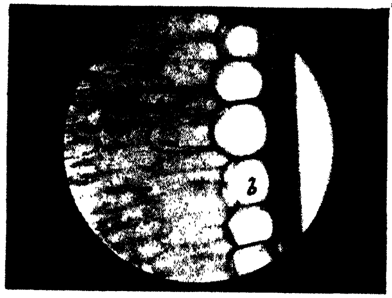

FIG. 2

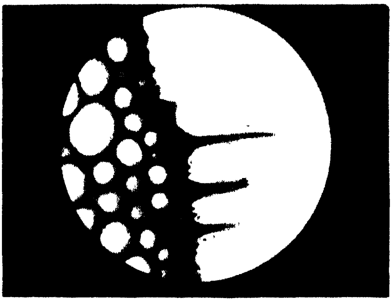

FIG. 3

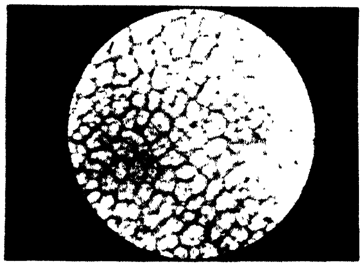

FIG. 4

FIG. 5

FIG. 6

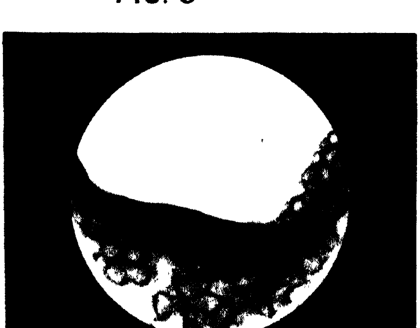

FIG. 7

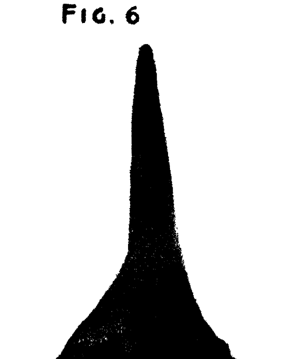

FIG. 8

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[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. I., 1922.]

ART. III.—*Description of a New Victorian Helichrysum.*

BY H. B. WILLIAMSON, F.L.S.

(With Plate V.)

[Read 20th April, 1922.]

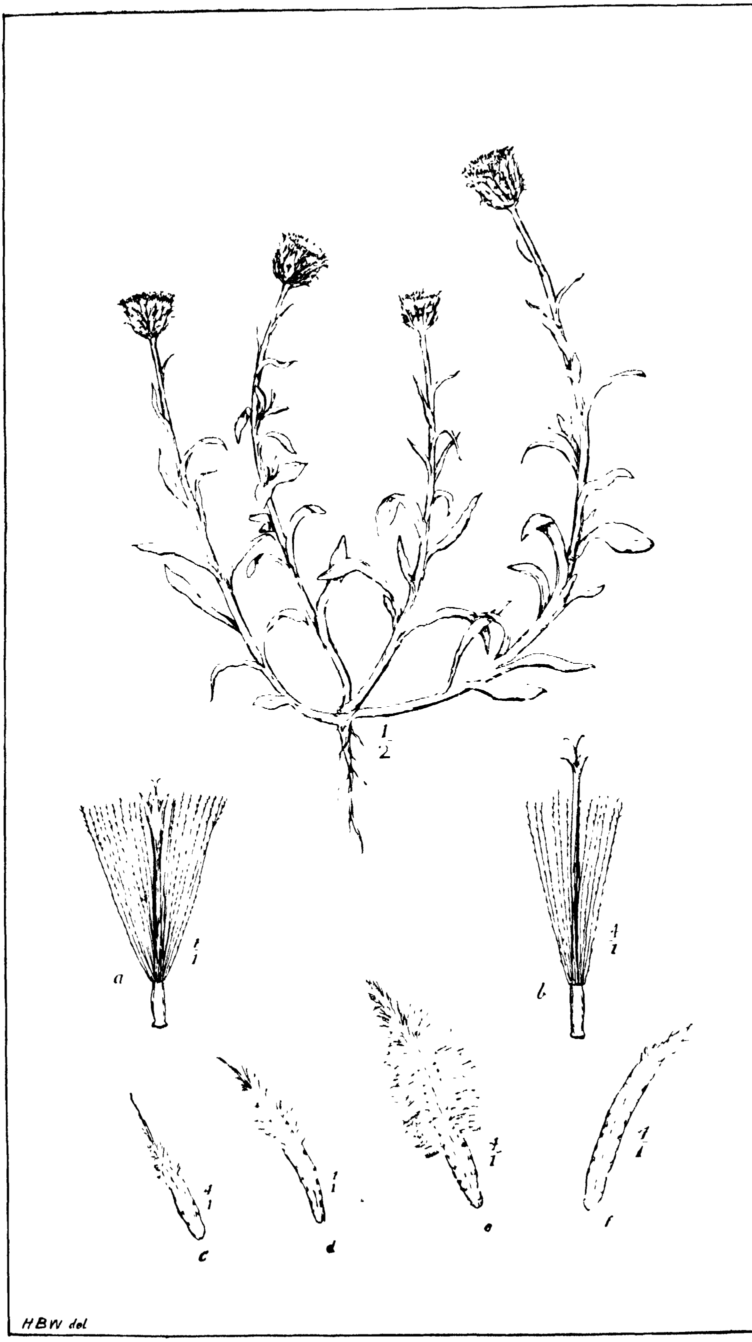
Helichrysum Gatesii, n sp.

Fruticulus humilis circiter 15 cm. altus, caulibus saepe occumbentibus rarius ramosis adpresse albo-lanatis, foliis alternis, subamplexicaulibus oblanceolatis vel linearibus subtus dense supra sparse albo-lanatis margine paulo recurvatis undulatisque 2-4 cm. longis 0.5-1 cm. latis, capitulis solitariis caules superne dissite foliatos terminantibus campanulatis circiter 1 cm. longis latisque, involucri bracteis numerosis plerumque longo-linearibus scariosis stramineis rugulosis ad apicem tenuibus ciliolatis aureis ruginosis subpatentibus, exterioribus brevioribus omnibus praeter intimas longe lanatis involucram vix superantibus, pappi setis circiter 20 inferne sparse barbellatis superne breviter plumosis, floribus foemineis paucis periphericis circiter 12 pappi setis instructis, acheniis glabris erostribus 1.5 mm. longis, pappi setis 6 mm. longis.

On hard dry ground on hillsides, Lorne, Vic. Rev. A. C. F. Gates, Dec. 7th, 1921. Flowering December to April.

A plant about 15 cm. high, with the habit and general aspect of *Leptorrhynchus Waitzia* or *L. pulchellus*, with alternate leaves, and with stems and the under side of the leaves woolly white. Flower heads solitary on rather long stems, with distant leafy bracts towards the flower heads. Involucral bracts not expanding into a ray, the outer ones shorter, and all embedded in cottony wool growing from their edges, wrinkled, and with light golden ciliate tips. Florets scarcely exceeding the involucre, with about 20 pappus bristlets excepting the few female florets which have about 12. All pappus bristlets sparsely barbellate below, shortly plumose at the summit. Achenes glabrous, not beaked.

Reference to page 612, vol. iii., Fl. Aust., will indicate the difficulty encountered in assigning a place to this plant. The bracts, consisting of woolly-edged linear claws point to *Ixiolaena*, but the numerous pappus bristlets plumose at the summit keep it out of that genus. It is here placed out of *Leptorrhynchus* on account of the shortness of the florets, and the absence of distinct upward narrowing of the achenes. It approaches near to *Helichrysum ambiguum*, Turcz. (*Leptorrhynchus*, Bth.), but that species has female florets with few or no pappus bristlets, and a very different involucre. From *H. rutidolepis* it is distinguished by having all flowers provided with at least 12 pappus bristlets, and by the short ciliate wrinkled laminae of the bracts.


1/2
a
b
c
d
e
f
HBW del

It may be considered as forming a link between sections Oxylepis and Chrysocephalum, and is placed next to *H. podolepideum*, its nearest affinity. That species (from Central Australia), has rather larger flower heads, with longer, and almost entire scarious tips to the bracts, stouter, shorter and almost bractless peduncles, leaves obovate and thick, which are densely clothed on both sides with a cottony wool, and resemble one of the forms of *H. apiculatum*.

It is rather strange that this plant has apparently never been sent to the National Herbarium, for it is not rare in the locality from which it is received. I am indebted to the Government Botanist, and to the officers of the Herbarium for the privilege of searching for and comparing material.

EXPLANATION OF PLATE V

Fig. *a*=Bisexual floret.
,, *b*=Female floret flower.
,, *c*, *d*, *e*, *f*= Bracts.

[PROC. ROY. SOC. VICTORIA, 35 (N S), PT. I., 1922.]

ART. IV.—*Studies in Australian Lepidoptera.*

BY A. JEFFERIS TURNER, M.D., F.E.S.

[Read 20th April, 1922.]

In this paper I have described a number of species from three localities, omitting the *Geometrites*, which are included in another publication.

(1) From a collection made by Mr. J. A. Kershaw on the Claudie River, in the Cape York Peninsula. This river, which is not marked in most maps, flows into Lloyd Bay to the north of Cape Direction, at about latitude 13°S. The area chiefly collected over was situated from seven to ten miles inland, and consisted of both open forest and dense tropical rainforest.

(2) A collection made in Tasmania by Mr. G. H. Hardy.

(3) Species captured by myself in the luxuriant rainforest and ferntree gullies of the Queensland National Park in the MacIntyre Range, at an altitude of 2000 to 4000 feet.

I have also taken this opportunity of completing and correcting my former revisions of five of the smaller families, the *Syntomidae*, *Uraniadae*, *Epiplemidae*, *Thyrididae*, and *Aegeriadae*, and have added a revision of the *Tineodidae*. A few new forms, of which it appears desirable to publish the descriptions, belonging to other groups, have been also included.

Fam. SYNTOMIDAE.

Since the publication of my revision (Proc. Lin. Soc., 1904, N.S.W., p. 834), I have described one new species (*Syntomis phaeochyta*, ib. 1906, p. 678), and I have now several more.

CERYX AFFINIS.

Ceryx affinis, Roths., Nov. Zool., 1910, p. 429, and 1911, pl. iii., fig. 15. Hmps., Cat. Lep. Phal. Suppl. i., p. 4.

I have not seen this species. It should be recognisable by the orange abdominal rings being interrupted on dorsum except on penultimate segment.

N.Q., Kuranda, near Cairns (Dodd). Also from New Guinea.

CERYX RHYSOPTILA, n. sp.

♂ 25-30 mm. Head blackish; face and back of crown orange-yellow. Palpi yellow. Antennae blackish; in ♂ simple, minutely ciliated. Thorax black; tegulae and patagia orange-yellow. Abdomen black with six orange-yellow rings; tuft black. Legs blackish; femora and tibiae suffused with yellowish on inner surface; anterior tibiae and tarsi thickened with rough scales, yellow on inner sur-

face. Forewings narrow; black with hyaline colourless spots; an elongate-triangular spot in cell; a larger spot between this and dorsum, extended towards base and tornus; an elongate-oval, undivided subapical spot; a circular supratornal spot, nearly equally divided; cilia black. Hindwings small, somewhat shrivelled, termen indented above tornus; black, an irregular orange-yellow basal spot, with a rounded median projection, cilia black.

N.Q., Evelyn Scrub, near Herberton, in November and December; two specimens received from Mr. F. P. Dodd.

Syntomis xanthosoma.

Amata tunneyi, Roths., Nov. Zool., 1910, p. 431, and 1911, Pl. iii., fig. 44. Hmps., Cat. Lep. Phal. Suppl. i., p. 14, is a synonym.

N.W.A., Derby; two examples taken by Mr. W. D. Dodd received from the South Australian Museum.

Syntomis pactolina.

Q., Brisbane, in October; one specimen differing from the type in the distal spot of the hindwing being smaller and separated for the most part from proximal spot, confluent only beneath costa.

Syntomis amoenaria.

Syntomis amoenaria, Swin., Ann. Mag. Nat. Hist. (7), ix., p. 418 (1902). Hmps., l.c., p. 20.

I have not seen this species.

N.W.A., Roeburne.

Syntomis pyrocoma.

Hampson records this as *cingulata*, Butl., but that name is preoccupied in the genus (Weber, 1801). I am not sure that *melitospila*, Turn., is more than a local race of this species.

Syntomis microspila, n. sp.

♂ ♀ 29-30 mm. Head orange, with some fuscous scales between antennae. Palpi dark fuscous. Antennae dark fuscous; apices white; in ♂ slightly serrate. Thorax dark fuscous, tegulae orange; sometimes with a few orange scales at posterior apex. Abdomen dark fuscous, with 7 orange rings in ♂, 6 in ♀; tuft dark fuscous, in ♀ whitish at apex. Legs dark fuscous; anterior tibiae with an orange tuft on under-side. Forewings elongate; dark fuscous, with small dull orange spots tending towards obsolescence; basal and sub-dorsal spots more or less quadrangular; spot in cell subtriangular; subapical spot nearly or wholly obsolete; supratornal very small, nearly equally divided; cilia dark fuscous. Hindwings dark fuscous; a moderate or small basal spot, nearly or quite obsolete on costal side of median; a very small undivided distal spot sometimes nearly obsolete; cilia dark fuscous.

Allied to *S. insularis*, but differing in the great reduction or obsolescence of the distal spots in both wings, and with intermediate spot wholly absent.

N.Q., Cooktown, in December; Kuranda, near Cairns, in January; three specimens.

SYNTOMIS OCHROSPILA, n.sp.

♂ ♀ 25-30 mm. Head dark fuscous; face, back of crown, and behind eyes yellow. Palpi dark fuscous. Antennae dark fuscous; in ♂ shortly bipectinate.(1) Thorax dark fuscous; tegulae and a posterior spot yellow. Abdomen dark fuscous with 7 orange-yellow rings in ♂, 6 in ♀; tuft dark fuscous, with an orange-yellow spot on dorsum, larger in ♀. Legs dark fuscous. Forewings moderately broad; dark fuscous; spots moderate, whitish-ochreous; basal spot small; dorsal spot elongate, oblique, often with a small spot or dot above it; spot in cell subtriangular; subapical spot elongate, rarely with a dot above it at apex; supratornal spot moderate, equally divided; cilia dark fuscous. Hindwings dark fuscous; basal spot moderate or rather small; distal spot moderate, unequally divided, the upper segment very small; cilia dark fuscous.

Easily distinguished by the pale-spotted wings, dark fuscous patagia, and abdominal tuft, and pectinate ♂ antennae.

N.Q., Ingham, in April and May; four specimens received from Mr. G. N. Goldfinch.

ERESSA MEGALOSPILIA, nom. nov.

Eressa strepsimeris, Hmps., Cat. Lep. Phal. Suppl. i., p. 47, pl. iii., fig. 13, *nec.* Meyr.

This is the North Australian representative of the North Queensland *strepsimeris*, Meyr. (*xanthostacta*, Hmps.). It is larger than that species, the spots are much larger and more transparent, and the basal spots of hindwings are largely developed. Meyrick's type was from Bowen, and his description is of the small-spotted species.

N.A., Darwin, Daly River.

ERESSA PAUROSPILA, n. sp.

♂ 26-30 mm. Head blackish; face and an anterior spot on crown ochreous. Palpi blackish. Antennae blackish; in ♂ shortly bipectinate.(1) Thorax blackish with a posterior orange spot. Abdomen blackish, with six ochreous rings; first ring interrupted on both sides on dorsum; tuft blackish, at apex ochreous. Legs blackish. Forewings blackish, with five pale-ochreous, semi-translucent spots; first between basal part of cell and dorsum; second in cell; third very small beneath ¾ costa; fourth and fifth small, separated by vein 4, before middle of termen. Hindwings blackish; two ochreous spots; first basal, moderate, bisected by a blackish line on cubital vein; second minute, subapical.

Nearest *E. geographica*, but with fewer and smaller spots on wings, and only one spot on thorax

N.S.W., Bulli, in March; three specimens received from Mr. G. H. Hardy, who has presented the type to the Queensland Museum.

EUCHROMIA POLYMENA.

N.W.A., Wyndham; two specimens received from Mr. L. J. Newman. Previously the only Australian record for this wide-ranging species was a single specimen in the Macleay Museum, said to be from North Australia.

Fam. ARCTIADAE.

HESTIARCHA ATALA, n. sp.

♂ 30 mm. Head ochreous. Palpi short (about 1), porrect or somewhat drooping; ochreous, slightly fuscous-tinged. Antennae (broken short) ochreous; in ♂ simple, shortly ciliated (1). Thorax brownish-ochreous. Abdomen with apical half densely hairy on dorsum and sides; brownish-ochreous; beneath ochreous. Legs ochreous; anterior pair suffused with fuscous. Forewings elongate, posteriorly dilated, costa very slightly arched, apex rounded, termen scarcely oblique, rounded towards tornus; brownish-ochreous; cilia brownish-ochreous. Hindwings twice as broad as forewings, termen rounded; pale-ochreous; cilia pale-ochreous.

♀ Wings small, aborted, forewings when closed reaching nearly or quite as far as apex of abdomen.

In the ♂ the tongue is present but weakly developed. It differs from *Hestiarcha pyrrhopa*, Meyr., in the antennae not being pectinate, and vein 6 of forewings arising separately, not stalked with 7, 8; for I agree with Hampson that vein 9 is absent, not 6 as in Meyrick's diagnosis. Otherwise the peculiar neuration of both species is identical, except that in *atala*. the discocellulars of the hindwing, though weak are traceable, the cell being very short (about ¼). As these two forms agree in so many features, and must be allied, it would be unwise to separate them into two genera. The ♀ of *pyrrhopa* is unknown.

T., Mt. Wellington, in January and February; four examples (1, ♂ 3 ♀), all found at rest under stones by Mr. G. H. Hardy. One ♀ had emerged from a slight cocoon of silk and hairs. The types have been presented to the Queensland Museum.

HELIOSIA AKDUMENA, n. sp.

♂ 16-20 mm. Head brown-whitish; face and palpi ochreous-whitish. Antennae brown-whitish; in ♂ serrate, shortly ciliated (1/3), with longer bristles (1). Thorax and abdomen brown-whitish. Legs ochreous-whitish. Forewings elongate, costa rather strongly arched, apex round-pointed, termen obliquely rounded; brown-whitish; markings fuscous; median discal dots at 1/3 and 2/3; sometimes a suffused dorsal spot at 1/3; a faint outwardly-curved line from ½ costa to 2/3 dorsum; some suffusion on tornus and before

mid-termen; cilia ochreous-whitish. Hindwings with termen sinuate; ochreous-whitish; at apex sometimes fuscous-tinged.

N.Q., Kuranda, near Cairns, in July, August and October; four specimens received from Mr. F. P. Dodd.

Gen. **Panachranta,** nov.

Tongue present. Palpi slender, porrect, short, not reaching beyond frons. Antennae of ♂ shortly ciliated, with longer bristles. Tibial spurs moderate. Forewings with 2 from middle of cell, 3 from shortly before angle, 5 from slightly above angle, 6, 7, 8 stalked, 9 absent, 10 and 11 free, oblique. Hindwing with 2 from 2/3, 3, 4 from angle of cell stalked nearly to termen, 5 from well above angle, 6, 7 stalked, 8 from middle of cell; cell about 2/3.

Allied to *Brachiosia*, Hmps.

PANACHRANTA LIRIOLEUCA, n. sp.

♂ ♀ 22-25. Head white; face sometimes ochreous-tinged. Palpi pale-fuscous. Antennae white; in ♂ ochreous-tinged except towards base, ciliations ½, bristles 1. Thorax white; patagia ochreous-tinged. Abdomen white. Legs white; anterior pair more or less suffused with pale-fuscous; middle pair ochreous-tinged in ♂. Forewings moderately elongate, costa gently arched, apex round-pointed; termen slightly bowed, slightly oblique; white; costal edge sometimes ochreous; cilia white. Hindwings with termen rounded; white; cilia white.

N.Q., Cairns and Karanda, in September and October; four specimens.

MACADUMA STRONGYLA, n. sp.

♂ ♀ 16-19 mm. Head, palpi, and thorax in ♂ grey, in ♂ ochreous-tinged. Antennae grey; in ♂ ochreous-grey, shortly ciliated (½). Abdomen grey; in ♂ ochreous-grey with ochreous tuft. Legs grey; in ♂ whitish-ochreous. Forewings short and broad, costa angled beyond middle, with a slight tuft at angle, slightly arched before angle, thence straight, apex and termen obtusely rounded; grey, in ♂ darker towards base and costa; costal edge ochreous in ♂, sometimes in ♀; a whitish discal dot at 3/5, absent in ♀; two finely dentate fuscous transverse lines; first at 2/5, very faint towards costa, in ♂ thickened towards dorsum; second from costal angle obliquely outwards, bent inwards in disc, and continued to dorsum at 4/5; cilia grey, on costa ochreous. Hindwings with termen rounded; grey; cilia grey.

N.Q., Kurunda, near Cairns, in September, October, March, April and May; six specimens received from Mr. F. P. Dodd.

Gen. **Eurypepla,** nov.

Palpi moderate, upturned, appressed to frons; second joint slender; terminal joint short, acute. Antennae in ♂ moderately ciliated. Tibial spurs long. Forewings rather broad; 2 from 2/3, 3 from well

before angle, 4 from angle, 5 from well above angle, 7, 8, 9 stalked, 7 arising after 9, 11 free. Hindwings broad, nearly circular, 2 from 3/4, 3 and 4 coincident, 5 from middle of cell, 6 and 7 long-stalked, 8 anastomosing with cell to 1/3.

EURYPEPLA PTERIDAULA, n. sp.

♂ 15-20 mm. Head ochreous-whitish. Palpi about 1; fuscous. Antennae fuscous; ciliatious in ♂ 1. Thorax fuscous. Abdomen grey. Legs pale-ochreous; anterior pair fuscous anteriorly; middle pair with some fuscous suffusion. Forewings broadly triangular, costa moderately arched, apex round-pointed, termen slightly bowed, oblique; fuscous; a pale-ochreous transverse fascia near base, constricted or interrupted in middle; a large whitish spot on 2/3 costa, giving rise to a slender dentate line, bent outwards in middle, and again inwards to end on 2/3 dorsum; sometimes a whitish dot on costa before apex, and several similar dots on termen; cilia pale-ochreous. Hindwings nearly circular, termen strongly rounded; a dense patch of audroconia in cell on upper surface; pale-ochreous, with some grey suffusion towards costa and termen; cilia ochreous-whitish.

Q., National Park (2000 to 4000 ft.) in December and January; nine specimens beaten from dead fronds of tree-ferns.

PHILENORA PTERIDOPOLA, n. sp.

♂ ♀ 17-18 mm. Head pale-yellow, lower edge of face fuscous. Palpi 1, obliquely porrect; dark-fuscous. Antennae fuscous; ciliations in ♂ very short (¼). Thorax fuscous. Abdomen pale-ochreous. Legs pale-ochreous; anterior and middle pairs suffused with fuscous. Forewings elongate-triangular, costa slightly arched, apex round-pointed, termen nearly straight, oblique; fuscous; markings pale-yellow; a basal patch on dorsum to 1/3, reaching about half across disc; a suffused inwardly oblique line from mid costa to end of dorsal basal patch; a triangular patch on dorsum beyond middle, extending nearly to tornus, joined by a fine dentate line from ¾ costa, at first parallel to termen, then bent inwards; two dark-fuscous discal dots beyond 1/3 and before 2/3; a subterminal suffusion; cilia pale-ochreous, bases broadly barred with fuscous. Hindwings with termen gently rounded; pale-ochreous; apical and costal area pale fuscous, joined by a suffused transverse median line from dorsum; cilia fuscous, on veins, tornus, and dorsum pale-ochreous.

N.Q., Evelyn Scrub, near Herberton (F. P. Dodd), in January and February; three specimens, which appear to belong to a local race, the forewings being yellower, and the basal patch larger, and extending nearly to costa.

Q., National Park (2500 to 4000 ft.), in December and January; ten specimens beaten from dead fronds of three-ferns.

THALLARACHA EPILEUCA, n. sp.

♂ ♀ 15-16 mm. Head white; face and palpi pale-grey. Antennae fuscous; in ♂ with short pectinations, each terminating in a tuft of

cilia and a longer bristle. Thorax white; bases of patagia sometimes fuscous. Abdomen grey; tuft ochreous-whitish. Legs grey; posterior pair paler. Forewings subtriangular, costa gently arched; apex tolerably pointed, termen obliquely rounded; fuscous; a broad white streak on dorsum from base to middle, its outline wavy; a large white circular spot on ¾ costa, nearly or quite confluent with a small subapical spot, the former with lower margin sometimes irregularly invaded by fuscous; sometimes a short white erect streak from tornus towards costal spot; cilia fuscous, on subapical spot white. Hindwings with termen rounded; pale-grey; cilia pale-grey.

N.Q., Herberton; two ♀ in January and February (F. P. Dodd). Q., Mt. Tambourine, ♂ type in October. There are slight differences which may be sexual or varietal.

THALLARCHA EPICELA, n. sp.

♀ 18-19 mm. Head white; face grey. Palpi fuscous or grey. Antennae pale-grey; bases white. Thorax white, with a fuscous spot before middle. Abdomen whitish-ochreous; bases of segments grey towards middle. Legs whitish-ochreous; anterior pair grey in front. Forewings subtriangular, costa gently arched, apex tolerably pointed, termen slightly bowed, oblique; fuscous with indications of pale waved transverse lines; a white spot on base of dorsum, reaching to ¼ dorsal edge, but forming a rounded or pointed process above dorsum beyond this; a large circular whitish spot on 2/3 costa, and a fine sinuate whitish transverse line beyond this, more or less distinct; a variably developed apical white spot; sometimes confluent white terminal spots above tornus; cilia fuscous, on apical spot whitish. Hindwings with termen rounded; ochreous-whitish; a grey discal spot on end of cell; a slight greyish apical suffusion; cilia ochreous-whitish.

Variable, and nearly allied to the preceding species; best distinguished by the differently shaped white dorsal mark, and the discal dot on hindwings.

Q., National Park (3000 ft.) in December and January; two specimens.

TERMESSA ORTHOCROSSA, n. sp.

♂ ♀ 30-32 mm. Head, palpi, thorax and abdomen yellow. Thorax with a blackish dot on anterior margin of each patagium. Antennae fuscous; in ♂ slightly laminate, ciliatious 1½. Legs yellow; tarsi dorsally barred with fuscous. Forewings broadly triangular, costa straight almost to apex, apex subrectangular, termen straight to near tornus, scarcely oblique; rather pale yellow; a slender blackish costal streak from base to 4/5, thickened into spots at base, 2/5, and 4/5; cilia blackish, interrupted by very narrow yellow bars opposite veins, on costa and tornus yellow. Hindwings with termen rounded, slightly bowed on vein 3; pale-yellow; a circular blackish submarginal spot below middle; cilia pale-yellow.

Q., Toowoomba, in October; four specimens received from Mr. W. B. Barnard.

Fam. NOCTUIDAE.

Subfam. AGARISTINAE.

Gen. **Prostheta,** nov.

Frons with a truncate conical prominence, at its apex a large circular depression with raised edge. Antennae dilated before apex. Palpi moderate, porrect; second joint covered with long, rough hairs; terminal joint short, hairy. Thorax and abdomen(?) not crested. Posterior tibiae with long rough hairs on dorsum. Neuration normal.

Intermediate in structure between *Periscepta*, Turn., and *Phalaenoides*, Lew., agreeing with the former in the palpi, with the latter in the antennae. I will not be sure of the absence of abdominal crests, as the type is not in the best condition. Specifically it is very different from species of both these genera.

PROSTHETA ACRYPTA, n. sp.

♂ 22 mm. Head blackish with lateral whitish streaks. Palpi blackish, towards base whitish; apex of second joint whitish. Thorax [abraded] blackish with whitish spots. Abdomen blackish with some whitish scales; a basal dorsal spot and tuft pale-ochreous. Legs blackish; tibiae and tarsi with whitish annulations; hairs on posterior tibiae ochreous. Forewings triangular, costa gently arched, apex round-pointed, termen bowed, slightly oblique; blackish with some whitish irroration and whitish-ochreous spots; a minute subcostal basal spot; a subcostal spot near base with another obliquely beyond it in disc; a spot beneath 1/3 costa, with another obliquely beyond it in disc; a spot beneath 2/3 costa, with another close beneath it; a series of subterminal spots, those in middle smaller; cilia blackish, on tornus white. Hindwings with termen rounded; orange-ochreous; a blackish discal spot on costal side of middle; a broad blackish terminal band containing a series of subterminal whitish spots; cilia blackish, mixed with whitish.

Type in South Australian Museum.

S.A., Tumby   ; one specimen.

Subfam. AGROTINAE.

AGROTIS POLIOTIS, Hmps.

Agrotis bromeana, Auriv., Arkiv. f. Zool., Stockholm. Band xiii., p. 16, T. i, f. 6. N.W.A., Broome.

A ♀ example admirably figured.

Subfam. MELANCHRINAE.

DASYGASTER PAMMACHA, n. sp.

♀ 23-24 mm. Head brownish with a few blackish scales; face paler with a pair of blackish spots above middle. Palpi slightly over 1; brownish with some dark-fuscous irroration. Thorax brownish-grey with a few blackish scales. Abdomen grey-brownish; densely

hairy on dorsum. Legs grey-brownish. Forewings elongate-triangular, costa almost straight, apex rectangular, termen straight, rounded beneath; whitish with a few scattered reddish-brown scales; a broad, somewhat irregular, dark-fuscous and reddish-brown median band from base to termen, irregularly expanded in middle, constricted before termen, triangularly expanded on termen; two similar terminal spots between this and tornus, the lower larger; similar dots on costa near base, at ¼, and middle; cilia reddish-brown mixed with fuscous and a few whitish scales. Hindwings with termen wavy, more deeply so beneath apex; fuscous; cilia pinkish-tinged, with median fuscous line and whitish apices. Underside fuscous with blackish discal mark at end of cell on hindwings.

T., Cradle Mountain, in December and January; two specimens from Mr. G. H. Hardy, the type presented to the Queensland Museum.

Subfam. ACRONYCTINAE.

Euplexia pamprepta, n. sp.

♂ 40 mm. Head white; centre of crown and lateral spots on face blackish. Palpi blackish; apices of three joints and inner surface of basal joint white. Antennae blackish; in ♂ minutely and evenly ciliated. Thorax blackish; tegulae brownish; posterior crest and bases of patagia white. Abdomen dark-fuscous, with dense whitish irroration except on penultimate segment. Legs blackish; tibiae and tarsi with white annulations; dorsum of posterior tibiae and tarsi with white annulations; dorsum of posterior tibiae whitish. Forewings elongate-triangular, costa slightly arched, apex round-pointed, termen bowed, moderately oblique, wavy; marked with white, blackish, and grey, with a few ochreous points; base white; a sub-basal blackish line angled outwards; triangular costal blotches at 1/5, 2/5, and 4/5, partly blackish, partly grey, and a smaller similar spot at 3/5; a sub-basal grey dorsal blotch; a dentate blackish line from ¼ costa to 1/3 dorsum; an irregular, central, partly grey, partly blackish, discal blotch beyond this line, surmounted by an ochreous dot on its posterior costal angle; followed by an angular white fascia; reniform broadly oval, outlined first with blackish, then with white, its centre grey above, ochreous beneath; a fine grey line traversing a white area from reniform to mid-dorsum; a grey postmedian fascia containing one or two ochreous dots, traversed by a dentate, blackish line, posteriorly edged with white, from ¾ costa, at first bent outwards, then strongly sinuate inwards to 2/3 dorsum; a strong white subterminal line, angled outwards, and touching termen in middle, angled inwards above dorsum; triangular blackish blotches on termen above middle and above tornus; cilia white, barred with blackish. Hindwings with termen gently rounded, wavy; grey-whitish with fuscous discal dot, postmedian line, and broad terminal fascia; cilia fuscous with white bars.

Q., National Park (3000 ft.), in December; one example in perfect condition at light.

Gen. **Syntheta.**

Syntheta Turn., P.L.S., N.S.W., 1902, p. 85.
Phaeopyra Hmps., Cat. Lep. Phal. vii., p. 19 (1908).
Phaeomorpha Turn., Tr. R.S., S.A., 1920, p. 149.

There is quite a tangle to be unravelled in the history of this genus. In describing it I made *xylitis* the type, but remarked that I referred *nigerrima* Gn. to the same genus, which I placed in Hampson's sub-family *Acronyctinae*. Hampson has adopted my genus for both species, but referred it to his *Noctuinae*, evidently on account of the origin of vein 5 of hindwings from near the lower angle of the cell. But this vein is only weakly developed, and in some *Acronyctinae*, for instance, *Euplexia dolorosa*, Wlk., vein 5 is quite as nearly approximated to 4 at its origin; and I now refer *nigerrima*, which has a well-developed series of abdominal crests to the genus *Euplexia*. It is a common species, and I venture to predict that the larvae, which should not remain long undiscovered, will prove to have all the prolegs fully developed.

Phaeopyra Hmps. is a synonym of *Syntheta*, and so is *Phaeomorpha Turn.* I distinguished the latter by the absence of a basal abdominal crest, but I find the crest is really present though small and often concealed by hairs. It will be as well to give a fresh diagnosis of the genus.

Frons not projecting. Palpi moderately long, ascending, appressed to frons; second joint thickened with loosely appressed scales; terminal joint moderate. Thorax with rounded anterior, and rather small, rough posterior crests. Abdomen with a small crest on dorsum of basal segment. Posterior tibiae hairy on dorsum. Forewings with neuration normal. Hindwings with 5 weakly developed, from much below middle of discocellulars (¼ to ⅕).

Antennae of ♂ in *xylitis* serrate, with tufts of cilia, and longer bristles; in *smaragditis* simple, evenly ciliated.

Syntheta xylitis.

Syntheta xylitis Turn., P.L.S., N.S.W., 1902, p. 85.
Euplexia chlorropis Turn., Tr. R.S., S.A., 1904, p. 213.
Phaeomorpha acincta Turn., Tr. R.S., S.A., 1920, p. 149.

The three forms I have described differ in coloration, but after careful comparison I have come to the conclusion that these differences are varietal only.

N.Q., Cairns, Townsville; Q., Biggenden, Nambour.

Syntheta smaragdistis.

Euplexia smaragdina B. Bak., Nov. Zool., 1906, p. 195, *praeocc.*
Trachea smaragdistis Hmps., Cat. Lep. Phal. vii., p. 137.

N.Q., Cairns, Innisfail; Q., National Park (3000 ft.); N.S.W., Richmond River. Also from New Guinea.

EUPLEXIA NIGERRIMA.

Mamestra nigerrima Gn., Noct. i., 200.

Q., Gympie, Brisbane, Mt. Tambourine, National Park (2000 ft.), Toowoomba, Killarney; N.S.W., Ebor, Sydney, Brewarrina; V., Melbourne, Moe, Gisborne, Birchip. T., Launceston. Hobart, W.A., Albany, Perth, Bridgetown, Narrogin.

Gen. Thalatha.

I find that the distinction given in my key (Tr. R.S., S.A., 1920, p. 140), between this genus and *Molvena* is untenable; I propose, therefore, to merge these two genera.

THALATHA MELANOPHRICA, n. sp.

♀ 34 mm. Head white, with a few blackish scales; face with central and lateral blackish dots. Palpi white; second joint blackish, except at base and apex. Antennae ochreous-grey, towards base whitish. Thorax ochreous-white, with some fuscous scales posteriorly. Abdomen ochreous-white, with some fuscous scales; apical segment except tuft mostly dark-fuscous. Legs whitish; tibiae and tarsi annulated with blackish. Forewings triangular, costa slightly arched, apex rounded-rectangular, termen bowed, slightly oblique; white, slightly ochreous-tinged; markings blackish; a basal spot; two costal dots near base; sub-basal dots in disc and on dorsum, two fine, parallel, interrupted, crenulate lines from costa before ¼ to dorsum beyond ¼; a dentate line from costa before middle to dorsum beyond middle, followed by some blackish suffusion; reniform indistinct, partly outlined by blackish marks, broadly oval; a longitudinal streak above dorsum towards tornus, crossed by a short transverse streak; four dots on apical third of costa; a fine, interrupted, irregularly dentate line from ⅚ costa twice bent outwards and crossing subdorsal streak; beyond this some blackish suffusion; a terminal series of dots, that above middle and that above tornus enlarged; cilia white barred with blackish. Hindwings with termen rounded, slightly wavy; white; towards termen suffused with grey; an interrupted fuscous terminal line; cilia white with some obscure fuscous dots.

Q., Clermont, in November; one specimen received from Mr. E. J. Dumigan.

Subfam. EUTELIANAE.

PHLEGETONIA PANTARCHA, n. sp.

♂ 38-40 mm. Head, brownish-grey. Palpi, 2, terminal joint ½; fuscous with whitish irroration, basal half of second joint fuscous externally. Antennae fuscous. Thorax grey, with a few fuscous scales. Abdomen grey, sometimes suffused with fuscous on dorsum. Legs fuscous, mixed with whitish. Forewings with costa straight, apex obtuse, termen crenulate, obtusely angled on vein 4; basal area dark-grey, with fuscous irroration, sharply defined by a nearly straight line from mid-costa to mid-dorsum; beyond this pale-grey, but suf-

fusedly darker towards termen; costa fuscous interrupted by whitish dots; reniform long, narrow, obliquely curved, upper end pointed; lower end broader, rectangular, the whole being shaped like an inverted comma, whitish, centre brownish narrowly outlined with fuscous; a triangular fuscous patch outside reniform, sharply produced to a point posteriorly, not always well defined; a fine fuscous line from upper end of reniform, describing a roughly circular line as far as vein 5, and then produced towards dorsum; a triangular fuscous costal patch before apex traversed by three or four pale streaks parallel to veins; two short parallel dark-fuscous streaks from $\frac{2}{3}$ dorsum, separated by a pale streak; a fine fuscous terminal line thickened on indentations; cilia dark-grey, apices reddish. Hindwings with termen rounded, crenulate; fuscous tinged with reddish, dorsal edge whitish with three dark-reddish dots before tornus; a dark-fuscous streak on vein 2, interrupted by two whitish dots; an ill-defined whitish tornal mark giving rise to a short whitish terminal line; terminal line and cilia as forewings, but bases of cilia whitish. Underside whitish, with numerous fuscous transverse lines and suffusion, and antemedian discal dot on hindwings.

Near *P. delatrix*, but larger, more distinctly marked, reniform differently shaped, not constricted, streak from $\frac{2}{3}$ dorsum double, posterior fuscous patch sharply pointed posteriorly, etc.

N.Q., Kuranda, near Cairns, in April; Q., National Park (3000 ft.), in March; two specimens.

Subfam. CATOCALINAE.

PARALLELIA ARCTOTAENIA.

Ophinsa arctotaenia, Gn., Noct., iii. p. 272.
Parallelia arctotaenia, Hmps., Cat. Lep., Phal. xii., p. 594, 594, Pl. 221, f. 7.

N.Q., Claudie River, in February; one specimen taken by Mr. J. A. Kershaw. Also from China, Japan, Ceylon, and India. Not previously recorded from Australia.

Subfam. NOCTUINAE.

RAPARNA LUGUBRIS, n. sp.

♂ ♀ 24-28 mm. Head fuscous or grey. Palpi moderate; terminal joint $\frac{1}{4}$ of second, rather stout, acute; fuscous. Antennae fuscous; in ♂ with moderate ciliations (1) and longer bristles, (2) Thorax grey. Abdomen grey, irrorated with dark-fuscous. Legs dark-fuscous. Forewings triangular, costa slightly sinuate, apex rounded-rectangular, termen bowed, scarcely oblique; fuscous; four blackish costal dots at $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{5}{8}$, of these all but the first give rise to extremely fine dentate blackish transverse lines to dorsum; postmedian line with minute whitish dots at apices of external dentations; subterminal represented by some whitish dots, with a larger costal dot before apex; cilia fuscous, apices partly whitish. Hindwings like forewings, but without costal markings and subterminal line; post-

median line ochreous. Underside with bases of wings more or less suffused with ochreous in ♂.

Near *R. horcialis (horcinsalis)*, Wlk.

N.A., Port Darwin, in January; four specimens received from Mr. G. F. Hill and Mr. F. P. Dodd.

RAPARNA CROCOPHARA, n. sp.

♀ 18 mm. Head yellow. Palpi long, recurved; second joint stout, smooth-scaled; terminal joint as long as second, slender, acute; yellow with a few purplish scales. Antennae fuscous, towards base ochreous-tinged. Thorax yellow. Abdomen and legs ochreous-grey. Forewings triangular, costa nearly straight, apex round-pointed, termen very slightly bowed, scarcely oblique, crenulate; orange-yellow, with reddish or purplish markings; a broad transverse line, its centre leaden-fuscous, at $\frac{1}{5}$, with a slight outward tooth below middle; a similar costal line from base to first line; a sub-basal spot; a leaden-fuscous dot surrounded by reddish scales on mid-costa; a minute, fuscous median discal dot; second line at $\frac{2}{3}$, similar to first, wavy; some reddish irroration between second line and termen; cilia purple-grey, at apex yellow. Hindwings like forewings, but without first line; second line not reaching costa.

Near *R. transversa*, Moore.

N.A., Port Darwin, in January. N.Q., Chillagoe, in March. Two specimens received from Mr. F. P. Dodd.

ANOMIS DEFINATA.

Anomis definata, Luc., P.L.S., N.S.W., 1893, p. 146.

Cosmophila psamathodes, Turn., P.L.S., N.S.W., 1902, p. 108.

N.Q., Cairns, Innisfail, Q., Nambour, Stradbroke I.

Fam. SPHINGIDAE.

HOPLIOCNEME MARMORATA.

Sphinx marmorata, Luc., "Queenslander," May, 1891, and P.L.S., N.S,W., 1891, p. 278.

♀ 50-60 mm. Head and palpi fuscous, mixed with whitish, appearing grey. Antennae whitish. Thorax fuscous, mixed with whitish, appearing grey; apices of tegulae sometimes whitish-ochreous. Abdomen blackish on dorsum, with lateral series of large oblong whitish-ochreous spots, and a central series of narrow whitish marks on apices of segments; two apical segments fuscous irrorated with whitish; underside mostly whitish. Legs fuscous, with whitish irroation. Forewings narrowly triangular, costa straight to $\frac{4}{5}$, thence arched, apex pointed, termen slightly bowed, oblique; fuscous densely irrorated, with whitish, appearing grey; an ill-defined, dark-fuscous mark on costa at $\frac{1}{3}$; an ill-defined, oblique, whitish shade from apex towards mid-dorsum, but lost in disc; beyond this a series of dark-fuscous, longitudinal, interneural streaks; veins towards termen narrowly fuscous; cilia whitish, interrupted with fuscous on veins.

Hindwings with termen slightly rounded; grey, towards base whitish, peripheral veins outlined with fuscous; cilia as forewings.

Agrees in structure with *H. brachycera*, Low, which I took at the same time and place, but that species has the forewings darker, with discal spot and transverse lines, and the abdomen has not a central series of whitish marks.

Q., Duaringa, Emerald, in March; one ♂ from Mr. W. B. Barnard, Clermont, in April; one ♀ from Mr. E. Q. J. Donnigan, Charleville, in September; six specimens at light, all of the same ♀ sex. N.S.W., Brewarrina, one specimen received from Mr. W. W. Froggatt.

♂ 54 mm. Differs from ♀ in lateral and posterior margins of thorax being suffused with whitish; a whitish suffusion from base of forewing along dorsum, meeting a broadly suffused whitish post-median fascia, acutely angled in middle posteriorly, containing a fuscous discal dot near its anterior margin; terminal areas, with some whitish suffusion.

Fam. URANIADAE.

A few additions and corrections have to be made in my former revision of this and the following families (Ann. Queensland Mus., 1911, p. 70).

ALCIDIS ZODIACA.

Alcidis zodiaca, Butl., Ent. Mo. Mag., 1869, p. 273.

Also from New Guinea.

Gen. STROPHIDIA.

Strophidia, Hb., Verz., p. 290, Hmps., Moths, Ind. iii. p. 113.

Palpi moderately long, smooth, slender; terminal joint longer than second. Antennae slender; in ♂ minutely ciliated. Forewings with cell about $\frac{1}{3}$: 3 and 4 connate, 6 and 7 stalked, 8 and 9 stalked, 10 and 11 separate from cell. Hindwings with a short acute projection on vein 4; cell about $\frac{1}{3}$; middle, 6 and 3 and 4 connate, 5 from above middle, 6 and 7 separate.

Type, *S. fasciata*, Cram.

STROPHIDIA FASCIATA.

Geometra fasciata Cram., Pap. Exot. ii., p. 12, pl. 104, f. D.
Phalaena caudata, Fab., Ent. Syst. iii. (2), p. 163.
Micronia obtusata, Gn, Lep. x., p. 25, Pl. v. f.6.
Strophidia fasciata, Hmps., Moths, Ind., iii. p. 114.

♂ 60 mm., Head and thorax white. Palpi blackish above, white beneath. Antennae grey, becoming white towards base; in ♂ filiform, minutely ciliated. Abdomen grey-whitish. Legs whitish; internal surface of anterior pair grey. Forewings broadly triangular, costa strongly arched, apex acutely rectangular, termen straight, slightly oblique; white; numerous black costal strigulae; nine straight fasciae, consisting of two or more series of fine grey strigulae, except the ninth, which is single; first four fasciae outwardly oblique, fifth transverse, sixth and seventh convergent and fused before dorsum; eighth and

ninth convergent; a pronounced blackish terminal line; cilia white, apices grey. Hindwings with termen straight, angled and with a strong acute projection on vein 4; with 5 fasciae similar to those on forewing, outwardly oblique, not reaching termen; a subterminal, angled fascia of grey strigulae; terminal line as forewing, but widely interrupted at base of projection; projection with three blackish dots, one on each side of base, the third on inner margin before apex.

N.Q., Claudie River, in December; one specimen taken by Mr. J. A. Kershaw. Also from the Archipelago, Ceylon, and India.

Fam. EPIPLEMIDAE.

An examination of the types in the British Museum shows that I was mistaken in some of my identifications.

BALANTIUCHA LEUCOCEPHALA.

Erosia leucocephala, Wlk., Cat. Brit. Mus., xxvi., p. 1758.
Dirades platyphylla, Turn., Tr. R.S., S.A., 1903, p. 21.

BALANTIUCHA LEUCOCERA.

Dirades leucocera, Hmps., Ill. Het., viii., p. 102, pl. 150, fig. 13, Moths Ind. iii. p. 133.

BALANTIUCHA MUTANS.

Erosia mutans, Butl., A.M.N.H. (5), xix., p. 434 (1887).
Dirades seminigra, Warr., Nov. Zool., 1896, p. 346.

DIRADES LUGENS.

Epiplema lugens, Warr., Nov. Zool., 1897, p. 202.

CHAETOPYGA HORRIDA.

There is a doubt as to the true locality for this species. In the British Museum there are specimens labelled as from British Guiana. Should this be correct the species must be removed from the Australian fauna.

EPIPLEMA CONFLICTARIA.

Epiplema lacteata, Warr., Nov. Zool., 1896, p. 276.
Epiplema perpolita, Warr., ib. 1896, p. 349.

EPIPLEMA ANGULATA.

Epiplema angulata, Warr., Nov. Zool., 1896, p. 275.
Epiplema schematica, Turn., Ann, Q. Mus., 1911, p. 83.

Also from New Guinea and Amboyna.

Fam. THYRIDIDAE.

Some additions and corrections to my revision were published in the Proc. Roy. Soc., Q., 1915, p. 26, and to these I shall not further refer.

OXYCOPHINA THEORINA.

Siculodes fenestrata, Pagen., Nass., Jahr, f. Nat., 1888, p. 183.

Also from Amboyna.

Gen. **Trophoessa.**

I based this genus on the stalking of veins 9 and 10 in the forewings, but examination of a series shows that this is inconstant; 9 and 10 may arise separately. The genus must therefore be dropped, and probably the type species must be merged with the following.

STRIGLINA MYRTAEA.

Phalaena (Noctua), myrtaea Drury Ins. Exot. ii., p. 4, pl. ii., f. 3 (1773).
Thermesia fenestrina, Feld, Reise, Nov., pl. 117, f. 2.
Striglina clathrula, Gn., Ann. Soc., Ent., Fr., 1877, p. 285.
Durdara fenestrata, Moore, P.Z.S., 1883, p. 27, pl. vi., f. 6.
Microsca plagifera, Butl., Tr. E.S., 1886, p. 420.
Durdara ovifera, Butl., P.Z.S., 1892, p. 129, pl. vi., f. 7.
Letchena satelles, Warr., Nov., Zool., 1906, p. 64.
Trophoessa daphoena, Turn., Ann., Q. Mus., 1911, p. 99.

N.Q., Cairns. Also from the Archipelago, India, and Mauritius.

STRIGLINA CITRODES, n. sp.

♂ 24 mm. Head, palpi, and antennae pale-brownish. Thorax pale-yellow; tegulae pale-brownish. Abdomen pale-brownish; basal and apical segments pale-yellow. Legs brownish; posterior pair and apical half of middle tibiae pale-yellow. Forewings triangular, costa nearly straight, apex acute, termen slighly bowed, slightly oblique; 7 and 8 short-stalked; very pale yellow, with faintly darker strigulae forming indistinct transverse lines; costal edge and strigulae brown, with four elongate brown spots beyond middle, the last apical; a fine brown line from second costal spot, at $\frac{3}{4}$ to $\frac{3}{5}$ dorsum; cilia pale-yellow. Hindwings with termen very slightly rounded; colour, irregular lines of strigulae and cilia as forewings. Underside similar, but strigulae brown and more distinct, post-median line of forewings broadened into an irregular fascia.

The stalking of 7 and 8 of forewings would put this in Hampson's genus, *Plagiosella*, but the stalking is very short on one side, and may not be constant. Taking the neurational variation of the preceding species into consideration, it appears safer to regard this as a *Striglina.*

Q., Mount Tambourine, in November; one specimen.

STRIGLINA MYRSALIS.

Pyralis myrsusalis, Wlk., Cat. Brit. Mus., xix. p. 892.
Letchena elaralis, Wlk., ib. xix., p. 901.
Pyralis idalialis, Wlk., ib. xix., p. 903.
Siculodes cinereola, Feld., Reise, Nov., pl. 134, fig. 8.

Striglina scallula, Gn., Ann. Soc., Ent., Fr., 1877, p. 287.
Durdara pyraliata, Moore, Lep., Atk., p. 177.
Durdara lobata, Moore, Lep. Atk., p. 177.
Durdara zonula, Swin., P.Z.S., 1885, p. 469, Pl. 28, f. 12.
Striglina radiata, Pagent., Iris, v., p. 41.

STRIGLINA LOCEALIS.

Pyralis loceusalis, Wlk., Cat. Brit. Mus., xix., p. 903.
Pyralis thyralis, Wlk., ib., xxxiv., p. 1234.

N.Q., Kuranda, near Cairns, in October; one specimen received from Mr. F. P. Dodd. Also from Ceylon.

STRIGLINA CENTIGINOSA.

Morova ? innotata, Warr., Nov. Zool., 1904, p. 483.

STRIGLINA SCITARIA.

Drepanodes scitaria, Wlk., Cat. Brit. Mus., xxvi., p. 1488.
Anisodes pyriniata, Wlk., ib. xxvi., p. 1582.
Thermesia reticulata, Wlk., ib. xxxiii., p. 1062.
Laginia reticulata, Wlk., ib. xxxv., p. 1560.
Striglina lineola, Gn., Ann. Soc., Ent., Fr. 1877, p. 284.
Homodes thermesioides, Suel., Tijd. v. Ent., 1877, p. 28.
Sonagara strigosa, Moore, Lep. Atk., p. 180.
Sonagara strigipennis, Moore, Lep. Atk., p. 180.
Azazia navigatorum, Feld., Reise, Nov., pl. 117, fig. 4.
Sonagara superior, Butl., A.M.N.H. (5), xx., 433.
Sonagara vialis, Moore, P.Z.S., 1883, p. 27, Pl. vi. f. 9.
Timandra cancellata, Christ., Neue Lep., Amur., p 23.
Striglina curvilinea, Warr., Nov., Zool., 1905, p. 411.

RHODONEURA ALBIFERALIS.

Pyralis albiferalis, Wlk., Cat. Brit. Mus., xxxiv., p. 1524.
Banisia elongata, Warr., Nov., Zool., 1896, p. 340.

Also from New Guinea and Moluccas.

RHODONEURA ATRIPUNCTALIS.

Pyralis atripunctalis, Wlk., Cat. Brit. Mus., xxxiv., p. 1523.
Brixa australiae, Warr., Nov. Zool., 1908, p. 329.

Also from Java and India.

RHODONEURA DISSIMULANS.

This occurs in Borneo and India, but appears to be distinct from *tetragonata*, Warr., to which I referred it. The latter is not known from Australia, but *ordinaria*, Warr., is a synonym of *dissimulans*.

—RHODONEURA BASTIALIS.

Rhodoneura melilialis, Swin., A.M.N.H. (7), vi., p. 312, (1900).

Also from N.Q., Cooktown; Q., Duaringa.

– RHODONEURA POLYGRAPHALIS.

Rhodoneura marmorealis, Moore, P.Z.S., 1877, p. 617.
Rhodoneura denticulosa, Moore, Lep. Ceyl., iii., p. 267.

Also from N Q., Cooktown.

ADDAEA PUSILLA.

Microsca pusilla, Butl., A.M.N.H. (5), xx. p. 116.

This is the species I cited as *polyphoralis*, Wlk., in my former paper, but that name rightly belongs to the following species. The two have been mixed in the British Museum, and during my first examination of the series in that collection I must have made some mistake as to the type.

ADDAEA POLYPHORALIS.

This I identified by the description as *castaneata*. Warr., but wrongly. That species is not known from Australia.

ADDAEA FRAGILIS.

Addaea fragilis, Warr., Nov. Zool., 1899, p. 314.

N.Q., Cooktown. Also from Dammer Island.

Fam. PHYCITIDAE.

CEROPREPES MNIAROPIS.

Ceroprepes mniaropis, Turn., P.R.S.Q., 1903, p. 151.

♂ ♀ 22-26 mm. Antennae of ♂ unipectinate, pectinations 5, apical ¼ simple; basal joint large, with a short process directly backwards over vertex. Thorax with two pairs of long hair tufts on under surface, near anterior and posterior extremities. Posterior tibiae with a short dorsal tuft of hair scales from base.

The discovery of the ♂ confirms the position of this species in the genus *Ceroprepes*, though the cell of the hindwings is about ½; vein 7 of hindwings, though closely applied to 8, does not actually anastomose.

N.Q., Kuranda, near Cairns, in October; Q., Mt. Tambourine, in February; National Park (3000 ft.), in March. Three specimens.

Gen. **Ammatucha**, nov.

Frons flat. Tongue strong. Palpi moderately long (1½), curved upwards, slightly rough anteriorly; terminal joint ⅓, stout. Antennae of ♂ shortly serrate, towards apex simple, with minute ciliations; above basal joint flattened and elongated anteroposteriorly, with

an excavation on inner side containing a tuft of dense hairs. Thorax with anterior and posterior tufts of hair in ♂ on undersurface. Forewings, with a transverse ridge of raised scales before middle; 2, 3, 4, 5 approximated at origin, 8 and 9 stalked, 10 closely approximated to 8, 9, for some distance. Hindwings with cell less than ½; 2 from ¾, 3 from angle nearly connate with 4, 5, which are closely approximated for some distance, 6 and 7 connate, 7 closely applied to 8 for some distance, not actually anastomosing.

Nearly allied to *Ceroprepes*, but with very different ♂ antennae.

AMMATUCHA LATHRIA, n. sp.

♂ 20 mm. Head, palpi, antennae, and thorax fuscous-grey. Abdomen fuscous-grey; apices of segments and under surface whitish-ochreous; tuft fuscous-grey. Legs fuscous irrorated, and tarsi annulated, with ochreous-whitish. Forewings narrow, posteriorly dilated, apex rounded-rectangular; fuscous-grey, suffused with whitish, the absence of which leaves dark markings; a dark straight ridge of raised scales from $\frac{2}{5}$ dorsum transversely nearly to costa; a suffused line from $\frac{1}{3}$ costa, opposite this ridge, to about mid-dorsum; a pair of dots in disc at $\frac{2}{3}$, arranged transversely; a suffused line from apex, inwardly oblique, soon diverging, anterior limb to mid-dorsum, posterior to near end of dorsum; a suffused subterminal line; cilia grey. Hindwings dark-grey; cilia grey; with a darker sub-basal line.

Q., National Park (3000 ft.), in March; one specimen.

Fam. GALLERIADAE.

LAMORIA IDIOLEPIDA

♂ ♀ 28 mm. Head, palpi, antennae, thorax and abdomen grey-whitish, antennal ciliations in ♂ imperceptible. Legs grey-whitish, finely irrorated, except posterior pair, with fuscous. Forewings elongate, posteriorly moderately dilated, apex rounded, termen obliquely rounded; grey-whitish, costal margin and terminal area suffused with pale-fuscous; dark-fuscous dots in disc beneath costa shortly before and after middle; dark-fuscous points sparsely scattered, more numerous in terminal area, where they are arranged longitudinally between veins; cilia pale-fuscous. Hindwings with termen sinuate; whitish, suffused with greyish towards apex; cilia greyish, on tornus and dorsum whitish.

The dark points on forewings depend on large scales, which, viewed at one angle, appear whitish, with dark bases, at another angle the apices are dark and bases pale.

Q., Brisbane, in December; National Park (2500-3000 ft.), in January; two specimens.

LAMORIA PERIDIOTA, n. sp.

♂ 30-31 mm. Head and palpi ochreous-grey-whitish. Antennae ochreous-whitish, annulated with dark-fuscous; ciliations in ♂ 1/3 Thorax grey-whitish, tinged with green; bases of patagia brownish-

fuscous. Abdomen grey-whitish. Legs ochreous-whitish; middle tarsi annulated with fuscous; anterior pair mostly fuscous. Forewings with basal $\frac{1}{5}$ of costa folded on lower surface to form a pouch, including a large tuft of scent-scales; costa bisinuate, apex acute, termen sinuate, scarcely oblique; pale-green; a brownish-fuscous patch on base of costa; a suffused, bisinuate, fuscous line from $\frac{1}{4}$ costa to $\frac{2}{5}$ dorsum, preceded by some fuscous irroration above dorsum; an outwardly-oblique, oval, discal spot beneath mid-costa, brownish outlined with fuscous, a short dark-fuscous longitudinal mark beneath this, and a broad bar of brownish-fuscous suffusion extending to termen immediately beneath apex; a finely dentate, fuscous line from $\frac{3}{4}$ costa to $\frac{3}{4}$ dorsum, curved outwards in middle; an interrupted dark-fuscous terminal line, enlarged to form elongate marks beneath apex; cilia greenish, apices grey. Hindwings with termen sinuate; ochreous-grey-whitish; cilia concolorous.

Q., National Park (2500 to 3000 ft.), in December and January; two specimens.

Fam. CRAMBIDAE.

CRAMBUS AMMOPLOCEUS, n. sp.

"A spinner of sand."

♂ 24-27 mm. Head ochreous-whitish. Palpi 2; pale-grey; basal joint ochreous-whitish. Antennae grey, towards apex darker, towards base whitish. Thorax pale-grey. Abdomen ochreous-grey. Legs whitish grey. Forewings somewhat dilated posteriorly, costa straight, slightly arched before apex, apex rounded-rectangular, termen slightly bowed, scarcely oblique; whitish-grey more or less irrorated with darker-grey; an ill-defined whitish streak on basal half of fold; some fuscous terminal dots; cilia whitish with a pale-grey ante-median line. Hindwings whitish-grey, cilia whitish.

N.Q., Dunk Island; two specimens received from Mr. E. J. Banfield, who has also sent larval galleries and cocoons with pupae, which unfortunately did not survive. From these and from information received from Mr. Banfield, I gather that the larvae inhabit galleries several inches in length in the sand under *Casuarina* trees. The gallery is lined with grains in the sand fastened together with silk; the larva emerges from the gallery, seizes the end of a piece of casuarina stem that lies on the surface, and, biting off a convenient length, backs down to the bottom of the gallery, carrying the fragment with it. In captivity the pupae are found in egg-shaped cocoons of sand and silk.

Gen. **Notocrambus**, nov.

Frons flat. Tongue present. Labial palpi moderately long, broadly dilated with rough scales, not hairy; terminal joint moderate; antennae short (about $\frac{1}{2}$); ciliations in ♂ imperceptible. Thorax and abdomen stoutly built; thorax hairy beneath. Posterior tibiae, with two pairs of spurs. Forewings with 2 from $\frac{3}{4}$, 3 from before angle, 7 from upper angle, 8 and 9 stalked. Hindwings with 2 from $\frac{3}{4}$, 3,

4, 5 approximated at base from lower angle, 6 and 7 connate from upper angle, 7 approximated to or anastomosing with 12 for a short distance.

Allied to *Crambus*, differing in the comparatively short, broadly dilated, rough-scaled palpi, and hairy underside of thorax. Related also to the New Zealand *Orocrambus*, Meyr., but has not the hairy palpi and coxae of that genus.

NOTOCRAMBUS HOLOMELAS, n. sp.

♂ ♀ 20 mm. Head, antennae, thorax, abdomen, and legs blackish, Palpi, $2\frac{1}{4}$; blackish mixed with a few white scales. Forewings moderately broad, posteriorly dilated, costa straight, apex obtusely pointed, termen bowed, moderately oblique; blackish, sometimes with a few whitish scales in disc towards tornus; cilia fuscous. Hindwings with termen rounded; dark-fuscous, cilia fuscous.

T., Cradle Mountain (3000 to 3500 ft.), in January; three specimens received from Dr. R. J. Tillyard. Type in Coll. Lyell; two examples in poor condition in my own collection.

UBIDA HOLOMOCHLA.

Ubida holomochla, Turn., P.R.S.Q., 1904, p. 165.

I have received an example from Pt. Darwin (F. P. Dodd), very like type, and four from Claudie River (J. A. Kershaw), which show considerable variation. Three of the latter differ from type by having a dark streak along dorsum of forewing, and some fuscous suffusion on apex of hindwing, while in the fourth the dark markings are reduced to a minimum, being represented only by a slender median streak, and a fine post-median subcostal streak with two short streaks before termen between it and apex.

UBIDA HETAERICA.

Ubida hetacrica, Turn., Ann. Q. Mus., 1911, p. 112.

A ♂ example from Claudie River (J. A. Kershaw) is probably referable to this species. The costal edge of forewings, median streak, and a short streak running into termen above it, are white; there is also a white posterior spot on thorax.

UBIDA AMOCHLA, n. sp.

♂ 26 mm. ♀ 40 mm. Head and thorax whitish. Palpi in ♂ $2\frac{1}{2}$, in ♀ 4; whitish. Antennae whitish; pectinations in ♂ 1. Abdomen whitish; bases of segments on dorsum grey. Legs whitish; anterior pair grey. Forewings elongate-oblong, costa gently arched, apex rounded-rectangular, termen rounded, slightly oblique; whitish; in ♂ a very faint pale-grey subcostal streak from base to termen, and a short longitudinal streak in disc beneath cell; in ♀ a terminal series of blackish dots; cilia whitish. Hindwings with termen very slightly sinuate; whitish; in ♂ some grey suffusion towards apex; cilia whitish.

Type in National Museum, Melbourne.

N.Q., Claudie River and Lloyd Island, in January; two specimens taken by Mr. J. A. Kershaw.

Fam. SCHOENOBIADAE.

SCHOENOBIUS MELANOSTIGMUS, n. sp.

♂ 20-23 mm. Head and thorax white. Palpi extremely long (7); second joint with long rough hairs; terminal joint long, smooth; ochreous-whitish; antennae whitish. Abdomen whitish; tuft whitish. Legs whitish; anterior and middle pairs suffused with pale-fuscous. Forewings elongate, costa gently arched, apex round-pointed, termen slightly bowed, slightly oblique; 11 running into 12; white, sometimes faintly ochreous-tinged; a rather irregular black median spot at $\frac{2}{3}$ over lower angle of cell; cilia whitish or ochreous-white. Hindwings and cilia white. Underside whitish.

Type in National Museum, Melbourne.

N.Q., Claudie River in January and February; three specimens taken by Mr. J. A. Kershaw.

SCHOENOBIUS CROSSOSTICHUS, n. sp.

♂ ♀ 22-24 mm. Head and thorax ochreous-whitish. Palpi very long (6); second joint with a few long hairs; whitish with a few grey scales. Antennae whitish. Abdomen ochreous-whitish. Legs ochreous-whitish, tarsi tinged with grey. Forewings elongate, apex acute, terman straight, oblique, 11 running into 12, the latter separating close to costal edge; ochreous-whitish sparely irrorated with fuscous in dorsal half; a terminal series of blackish dots between veins; cilia ochreous-whitish. Hindwings and cilia white; underside whitish.

Type in National Museum, Melbourne.

N.Q., Claudie River in February; two specimens take by Mr. J. A. Kershaw.

Gen. **Styphlolepis**.

Styphlolepis, Hmps., P.Z.S., 1895, p. 912.

An Australian genus allied to *Cirrhochrista*, from which it may be distinguished by vein 7 of the hindwings being approximated to 12, or anastomosing at a point only, whereas in *Cirrhochrista* these veins anastomose for a considerable distance. The stalking of 6 and 7 of the forewings is an exceptional character in the genus, and is not constant in those species in which it occurs. The larvae are internal feeders, occurring often in dry districts. The perfect insects attain a large size, and, owing to their retired habits, are very seldom seen. The largest species hitherto discovered was bred from larvae found in a Brisbane suburban garden, in which the owner, a zealous entomologist, had worked and collected for thirty years, but had never previously seen the moth. Five species are at present known, of which two are here described; the other three are:—

squamosalis, Hmps., P.Z.S., 1895, p. 912, from N.Q., Townsville.

agenor, Turn., P.R.S.Q., 1915, p. 31, from Western N.S.W., Brewarrina, Gunnedah.

leucosticta, Hmps., Ann. Mag. Nat. Hist., (9), iv., p. 318, (1919), from N.W.A., Sherlock River.

Styphlolepis raaua, Swin., Ann. Mag. Nat. Hist. (7), vi. p. 313 (1900), from N.Q., Townsville; Q., Bundaberg, Brisbane; N.S.W., Lismore, does not belong to the genus. It is a true *Cirrhochrista*.

STYPHLOLEPIS PERIBARYS, n. sp.

♂ 48 mm., ♀ 55 mm. Head and thorax reddish-brown, mixed with white. Palpi and antennae reddish-brown. Abdomen white. Legs white; anterior pair reddish-brown. Forewings triangular, costa straight, arched towards apex, apex pointed, termen doubly sinuate, oblique; white copiously irrorated with reddish-brown, which tends to form transverse strigulae; two, slender, transverse, reddish-brown lines; first from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum, beneath costa outwardly-curved, thence straight; second similar from $\frac{3}{4}$ costa to $\frac{3}{4}$ dorsum; cilia reddish-brown, with a whitish subapical line and apices pale-fuscous. Hindwings with termen gently rounded, slightly wavy; white; a reddish-brown terminal line not reaching tornus; cilia white, bases tinged with reddish-brown.

Veins 6 and 7 of forewings are connate, or closely approximated at origin in both sexes.

Q., Emerald, in May; two specimens received from Mr. W. B. Barnard.

STYPHLOLEPIS HYPERMEGAS, n. sp.

♂ 46 mm., ♀ 66 mm. Head pale red. Palpi 3; fuscous brown; lower edge white nearly to apex. Antennae grey; in ♂ thickened, simple. Thorax ochreous-brown, with a central pale red spot. Abdomen brown; sides and under-surface whitish. Legs white; anterior tarsi and inner surface of anterior femora and tibiae fuscous-brown. Forewings triangular, costa, strongly arched, apex rounded, termen sinuate towards apex and tornus, strongly bowed in middle, brown inclining towards grey in costal area, with sparsely scattered, large, dark-fuscous scales; a large subdorsal suffusion from near base, where it is broadest, nearly to termen, whitish mostly suffused with pale-red and containing also some dark-fuscous scales; a fuscous line from $\frac{2}{3}$ costa to $\frac{1}{3}$ dorsum; a suffused discal fuscous mark beyond middle; a second fuscous line from $\frac{4}{5}$ costa, bent slightly outwards beneath costa, thence nearly straight to $\frac{2}{3}$ dorsum; cilia dark-fuscous with a white spot in sinuation above tornus. Hindwings with termen rounded; brownish-ochreous becoming paler towards base; a narrow-grey terminal suffusion produced inwards on veins; a wavy curved transverse line at about $\frac{2}{3}$. becoming obsolete towards dorsum; cilia fuscous more or less mixed with white, wholly white on tornus and dorsum.

Q., Brisbane in October; two specimens received from Mr. R. Illidge, bred from larvae.

Fam. PYRALIDAE.

Gen. LABODRYAS, nov.

Frons flat. Tongue well-developed, thickly scaled towards base. Labial palpi moderate, straight, drooping, smooth-scaled; terminal joint obtuse with some rough scales at apex. Maxillary palpi obtuse and rough-scaled at apex. Antennae of ♂ slightly laminate, with moderately long ciliations. Forewings with 2 from $\frac{3}{4}$, 3 from well before angle, 4 and 5 connate from angle, which is acutely produced, diverging, 7, 8, 9 stalked, 10 and 11 from cell, free. Hindwings with 2 from $\frac{2}{3}$, 3 from well before angle, 4 and 5 connate from angle, 6 and 7 connate, 7 anastomosing strongly with 8.

Nearest *Ocnogenes*, Meyr., but the palpi are very different.

LABODRYAS HAPLOCALA, n. sp.

♂ 18 mm. Head ochreous-whitish; face fuscous. Palpi dark-fuscous. Antennae grey, towards base ochreous-whitish; ciliations in ♂ $1\frac{1}{2}$. Thorax ochreous-whitish, mixed with fuscous-green. Abdomen dark-fuscous, beneath whitish-ochreous. Legs dark-fuscous; tibiae and tarsi annulated with ochreous-whitish. Forewings elongate-triangular, costa sinuate, apex rounded, termen bowed, oblique; purple-grey; base fuscous-green, continuous with a broad fuscous-green costal streak to apex; a whitish transverse line from $\frac{1}{3}$ costa to mid-dorsum, strongly curved outwards in middle, edged anteriorly by a fuscous-green fascia containing some dark-fuscous scales, posteriorly by a dark-fuscous line; a second whitish line from $\frac{3}{4}$ costa to tornus, bent outwards above middle, thence strongly inwards, edged anteriorly by a dark-fuscous line, posteriorly by a fuscous-green and dark-fuscous fascia; four whitish costal dots between lines; a dark-fuscous discal spot beneath mid-costa; a terminal series of dark-fuscous dots edge with fuscous-green; cilia purple-grey, with four large whitish bars. Hindwings with termen gently rounded; grey, towards base, and tornus suffused with whitish; two fine grey transverse lines, first from mid-dorsum strongly curved towards base of costa; second from above tornus to costa beyond middle, wavy; a terminal series of fuscous dots; cilia grey with basal and median whitish lines.

Q., National Park (3000 ft.), in March; one specimen.

Fam. PYRAUSTIDAE.

MUSOTIMA CALLIDRYAS, n. sp.

♂ ♀ 11-12 mm. Head, thorax, and abdomen fuscous. Palpi whitish; second joint with apical, third joint with subapical dark-fuscous ring. Antennae with joints dilated at apices; grey-whitish, on dorsum barred with dark-fuscous. Legs fuscous; tarsi broadly annulated with whitish. Forewings strongly dilated posteriorly, costa gently arched, apex rounded, termen deeply incised beneath apex, and above tornus, oblique; whitish densely suffused with fuscous; a small darker basal patch outlined with whitish; an outwardly-curved fuscous

line from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum, edged anteriorly with whitish; median area in ♂ broadly whitish; a second, less distinct line from $\frac{2}{3}$ costa, at first curved strongly outwards, then sinuate and inwardly-oblique to $\frac{2}{3}$ dorsum; a short, white, outwardly-oblique, subapical streak, a similar streak parallel to termen between incisions, and a third streak below lower incision; a brownish terminal line interrupted by incisions, cilia fuscous with a dark-fuscous basal line, on apex and incisions whitish. Hindwings with termen nearly straight and deeply incised beneath apex; fuscous; basal part of costal area whitish; a fine, dentate, whitish, transverse line at about $\frac{1}{4}$; a large, median, subdorsal, white spot, suffusedly connected with costal area; replaced in ♂ by a broad whitish fascia; a second whitish line at about $\frac{3}{4}$; bent inwards beneath middle; four blackish terminal spots preceded by fine whitish lunules; cilia fuscous, apices whitish.

Q., National Park (2500-3500 ft.), in December and January; four specimens.

SYLEPTA PHAEOPLEURA, n. sp.

♂ 20 mm. Head ochreous-whitish; face dark-fuscous. Palpi dark-fuscous, with a sharply defined, oblique, whitish, basal patch. Antennae and thorax ochreous-whitish. Abdomen ochreous-whitish; dorsum with two dark-fuscous dots on third segment, and median fuscous spots on three last segments. Legs ochreous-whitish; anterior tarsi white broadly annulated, with dark-fuscous. Forewings triangular, costa straight to $\frac{3}{4}$, thence arched, apex round-pointed, termen slightly bowed, oblique; brown-whitish; markings dark-fuscous; a costal streak throughout, interrupted by four pale dots in terminal $\frac{1}{4}$, with a slight discal projection at $\frac{1}{5}$, and a larger acute blackish projection in middle; an incomplete fine curved line at $\frac{1}{3}$; a finely dentate line from $\frac{4}{5}$ costa, bent inwards between veins 2 and 3, and again at right angles to end on dorsum; a terminal series of blackish dots on veins; cilia brown-whitish. Hindwings as forewings, but without costal streak and first line; second line not dentate, and succeeded by some fuscous suffusion.

Type in National Museum, Melbourne.

N.Q., Claudie River, in January; one specimen taken by Mr. J. A. Kershaw.

MARGARONIA APIOSPILA, n. sp.

♂ ♀ 21-25 mm. Head ochreous-whitish, centre of crown and face fuscous. Palpi, $1\frac{1}{2}$; ochreous-whitish; a narrow median bar, apex of second joint, and terminal joint blackish. Antennae whitish-ochreous. Thorax white, with a broad median fuscous line. Abdomen white; a median dorsal fuscous line on first four segments; a blackish dot on dorsum of terminal segment. Legs ochreous-whitish; anterior pair fuscous. Forewings rather narrowly triangular, costa straight to $\frac{3}{4}$, thence arched, apex pointed, termen sinuate oblique; fuscous; markings white; a line from beneath $\frac{1}{5}$ costa to $\frac{1}{4}$ dorsum; a large subquadrate spot shortly beyond this extending from nearly beneath costa $\frac{2}{3}$ across disc; a large subovate (pear-shaped) spot with larger end dorsal at $\frac{2}{3}$; a curved subterminal line, expanded on margins; cilia

whitish with an interrupted fuscous sub-basal line. Hindwings with apex pointed, termen sinuate; white; a transverse oval discal spot before middle, and a moderate terminal band; fuscous; cilia white, bases fuscous.

Near *microta*, Meyr., and *flavizonalis*, Hmps.; distinguished from the first by the white thorax and abdomen; from the second by the fuscous colouring without yellowish tinge, differently shaped posterior spot, and terminal band on hindwings.

N.Q., Cooktown in April; Cairns in October; Q., Coolangatta (and Cudgen, N.S.W.), in January and May; seven specimens.

Pyrausta hyalistis.

Pyrausta hyalistis, Low., P.L.S., N.S.W., 1901, p. 669.
Pyrausta diplosticta, Turn., Tr. R.S.S., S.A., 1908, p. 100.

V., Melbourne, Sale, Lorne, Upper Macedon, near Gisborne.

Eclipsiodes semigilva, n. sp.

Semigilvus, half-yellowish.

♂ 22 mm. Head pale-ochreous mixed with fuscous. Palpi 2½; dark-fuscous; base and internal surface, except apex, whitish. Antennae grey annulated with dark-fuscous, in ♂ slightly dentate with very short ciliations (¼). Thorax whitish, mixed with dark-fuscous; a posterior spot whitish. Abdomen pale-ochreous. Legs fuscous; tibiae and tarsi annulated with whitish; posterior pair, pale-ochreous, with fuscous annulations on tarsi. Forewings moderately narrow, costa slightly arched, apex tolerably pointed, termen nearly straight, moderately oblique; white, with fairly uniform dark-fuscous irroration; markings dark-fuscous; a suffused basal patch; a line from ⅙ costa to ⅓ dorsum; orbicular minutely outlined; reniform 8-shaped, outlined in fuscous, connected by a line with ⅔ dorsum, and by a large suffused spot with tornus; a finely dentate line from ⅘ costa to tornal spot; a subapical costal spot; cilia whitish mixed with grey, bases barred with dark-fuscous. Hindwings with termen slightly sinuate; pale-ochreous; a rather narrow fuscous terminal band not reaching tornus; cilia whitish, bases pale fuscous.

Type in Coll. Lyell.

V., Daytrap, in October; one specimen.

Scoparia ischnoptera, n. sp.

♂ 20 mm. Head grey. Palpi 4; fuscous; extreme base white. Antennae fuscous. Thorax fuscous-grey; pectus white. Abdomen pale-grey; base of dorsum ochreous-tinged. Legs grey. Forewings very narrow, slightly dilated posteriorly, apex round-pointed, termen bowed, oblique; dark-grey, inclining to fuscous; a blackish streak from base to middle along fold; a similar streak in cell from middle to ¾; some blackish subapical and subtornal suffusion; cilia whitish with two grey lines, basal line darker. Hindwings three times as broad as fore-

wings, termen gently rounded; whitish; slight grey-whitish suffusion towards apex; cilia whitish.

This species and the following are remarkable for their long palpi and narrow forewings. Type in Coll. Lyell.

V., Ringwood in April, one specimen.

SCOPARIA ITHYNTIS, n. sp.

♂ ♀ 14-16 mm. Head whitish. Palpi 4; fuscous, upper edge, and base of lower edge whitish. Antennae grey; ciliations in ♂ ½. Thorax fuscous. Abdomen pale-grey. Legs fuscous; posterior pair whitish. Forewings narrow, posteriorly dilated, apex acute, termen sinuate, oblique; whitish, irrorated with fuscous, more densely in ♀; an indistinct fuscous line from ¼ costa to ⅓ dorsum, inner edge suffusedly whitish, orbicular and claviform obsolete; reniform represented by a brownish-ferruginous spot; a whitish transverse line from ¾ costa to ¾ dorsum, angled outwardly, better defined in ♀; a whitish streak from apex towards or meeting second line at angle; cilia whitish, an interrupted sub-basal fuscous line, apices partly greyish. Hindwings 2½ times as broad as forewings, termen slightly sinuate; whitish, towards termen greyish-tinged; cilia whitish, usually with a fuscous subbasal line

Type in Coll. Lyell.

N.S.W., Adaminaby, in October; V., Gisborne, in September and October; fifteen specimens.

SCOPARIA MELANOXANTHA, n. sp.

♀ 18-19 mm. Head yellow, with a few blackish scales. Palpi 2; yellowish, with a few blackish scales. Antennae pale-ochreous, on dorsum barred with blackish. Thorax yellow; bases of patagia, a pair of posterior dots, and some scattered scales blackish. Abdomen pale-grey. Legs yellowish, tibiae and tarsi with obscure fuscous annulations. Forewings narrowly triangular, costa nearly straight, apex pointed, termen nearly straight, moderately oblique; yellow; markings blackish; a dot on costa near base; a short basal dorsal streak; a broad incomplete fascia from costa near base, outwardly-oblique, not reaching dorsum; a dot on fold beyond this; a second similar mark from costa reaching half across disc, and connected with a narrow suffusion on central half of costa; reniform 8 shaped, its upper half very thickly outlined, its lower very slenderly and incompletely; some blackish dorsal irroration; a triangular costal subapical spot; a large tornal spot, acutely produced halfway across disc, containing a yellow dot near tornus; a triangular spot on mid-termen; cilia yellowish with an interrupted fuscous basal line, and a grey subapical line. Hindwings with termen sinuate; ochreous-whitish, suffused with grey towards termen; cilia ochreous-whitish with a grey sub-basal line.

This and the following species are specifically very unlike anything else found in Australia.

Q., National Park (3000 ft.), in December; two specimens taken at light.

SCOPARIA GETHOSYNA, n. sp.

♀ 20 mm. Head brownish-orange. Palpi 3; ochreous-whitish with two broad oblique fuscous bars on external surface. Antennae grey. Thorax grey; patagia whitish-ochreous, bases orange. Abdomen pale ocheous-grey. Legs ochreous-whitish; tibiae and tarsi annulated, with fuscous. Forewings narrowly triangular, costa slightly arched, apex obtusely pointed, termen nearly straight, slightly oblique; brownish-orange; a large basal dark-fuscous spot, angled outwards, not reaching dorsum; an obscure, whitish, slightly outwardly curved line from ¼ costa to ⅓ dorsum; a squarish dark-fuscous blotch extending on costa from ¼ to middle, sharply limited beneath by fold; a whitish fascia beyond this, broad on costa and in disc, narrow near dorsum, containing some fuscous scales, and a dark fuscous line near, and parallel to its posterior edge; a large subapical, a supratornal, and a series of small terminal spots, dark-fuscous; cilia whitish, with a central grey line. Hindwings with termen slightly sinuate. ochreous-whitish; cilia ochreous-whitish.

Q., National Park (3000 ft.), in December; one specimen at light.

SCOPARIA CROCOSPILA, n. sp.

♀ 18 mm. Head blackish; face mixed with whitish. Palpi 2½; blackish; lower edge whitish towards base. Antennae whitish, finely barred with blackish. Thorax blackish, with a few whitish scales; apices of patagia whitish; a large posterior spot whitish suffused with orange. Abdomen fuscous; apices of segments narrowly whitish; underside whitish. Legs whitish with some blackish scales; tibiae and tarsi broadly annulated with blackish. Forewings moderate, costa gently arched, apex round-pointed, termen slightly rounded, slightly oblique; blackish; markings whitish; a suffused transverse sub-basal line; a more distinct slightly outwardly-curved line at ⅓; orbicular and claviform obsolete; reniform represented by two blackish spots separated by a whitish spot, and situated in a post-median whitish suffusion; a fine doubly-sinuate line from ⅚ costa to ¾ dorsum; a broader, irregularly crenated subterminal line; cilia ochreous-whitish, with sub-basal and apical series of dark-fuscous dots, the latter incompletely developed. Hindwings with termen slightly sinuate; grey; cilia ochreous whitish, with an incomplete series of grey median dots.

Type in Coll. Lyell. The orange thoracic spot, if constant, should make this species easily recognised.

V., Gisborne, in November; one specimen.

SCOPARIA AXIOLECTA, n. sp.

♀ 18 mm. Head white, between antennae blackish. Palpi 3; white mixed with fuscous. Antennae white, with blackish annulations. Thorax white, mixed with blackish and fuscous. Abdomen pale-grey. Legs whitish; anterior and middle tibiae irrorated with blackish; tarsi with blackish annulations, those on posterior pair only slightly developed. Forewings elongate-triangular, costa gently

arched, apex round-pointed, termen nearly straight, moderately oblique; white with well-defined blackish markings, and slight blackish irroration; a sub-basal fascia, expanded on dorsum, and containing a whitish dot; a line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum; an irregular discal mark beyond this, representing orbicular and claviform; reniform strongly marked, X shaped; indications of a curved line from $\frac{3}{4}$ costa to $\frac{2}{3}$ dorsum; rather large angular spots on costa before apex, on termen above middle, and on dorsum before tornus; an interrupted submaginal line; cilia white, bases obscurely barred with blackish. Hindwings with termen sinuate; whitish-grey; cilia whitish.

T., Cradle Mountain, in January; one specimen received from Dr. R. J. Tillyard. A second ♀ example from Mt. Macedon, Victoria (Coll. Lyell), appears to be the same species.

SCOPARIA TRISTICTA, n. sp.

♂ 21 mm. Head grey. Palpi $2\frac{1}{2}$; grey. Antennae grey; ciliations in ♂ minute. Thorax grey. Abdomen grey-whitish. Legs whitish; anterior and middle tibiae and tarsi annulated with dark-fuscous. Forewings elongate-triangular, costa gently arched, apex rounded-rectangular, termen slightly bowed, scarcely oblique; grey with slight dark-fuscous irroration; markings dark-fuscous; a small suffused spot on base of costa; a moderately broad line, slightly dentate in middle, from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, followed by some dark-fuscous suffusion; orbicular and claviform distinct, edged with dark-fuscous, pale in centre, well separated from each other, and first line; reniform broadly oval, indented posteriorly, outline and centre dark-fuscous, connected with a suffused spot on mid costa; second line from $\frac{4}{5}$ costa to $\frac{4}{5}$ dorsum, indented beneath costa, outwardly bowed in middle, thence inwardly oblique and wavy, edged posteriorly by a pale line; suffused spots in terminal area, first subapical, second on mid-termen, third supratornal; a subterminal dot above second spot; cilia whitish with a subapical series of fuscous dots. Hindwings with termen sinuate; whitish; cilia whitish.

N.S.W., Ebor (4000 ft.), in January; one specimen.

Fam. TINEODIDAE.

A small family of the group *Pyralites* characterised by the wide separation of vein 5 of the hindwings from 4; only in the new genus *Tanycnema* are these two veins somewhat approximate, but separate at origin. From it have arisen probably the two small families *Oxychirotidae* and *Coenolobidae*, each consisting of a single genus. More remotely related are the *Pterophoridae*, which may be distinguished from all genera of these three families, except *Tanycnema*, by the absence of maxillary palpi. As at present known the family consists of a few small Australian genera and the Indian genus *Simaethistis* (which, however, I have not seen). The family, as Meyrick has pointed out, is a primitive one, which was probably formerly much more largely developed. I imagine that it arose in

Southern Asia, and that in the remote past a few genera reached the Eastern Cordillera of this continent, when that consisted of a chain of islands surrounded by the ocean, and the old Australia lay many hundred miles to the west. Almost destroyed in its original habitat after the appearance of the dominant family *Pyraustidae*, a few genera have survived in these mountain-tops, or in the rain-forests at their bases, one genus, *Tineodes*, having become adapted to life on the coastal plains. I should expect that further representatives of the family will be found in the mountains of New Guinea.

The family may be divided into two groups; a more primitive, in which 6 of the hindwings is widely separate from 7; and a less primitive, in which these veins are connate from the upper angle of the cell. The latter group includes the exotic genus *Simaethistis*. It happens that the latter group also exhibits some primitive features; for instance, in *Simaethistis* and *Palaeodes*, all veins in the forewings are separate; and in the new genus *Anomima* 7 of the hindwings does not anastomose with 12, a structure which is shared only by the genus *Tanycnema*.

1.	Hindwings with 6 and 7 connate	2
	Hindwings with 6 remote	3
2.	Hindwings with 7 not anastomosing	Anomima
	Hindwings with 7 anastomosing	Palaeodes
3.	Hindwings with 4 and 5 somewhat approximate at origin	Tanycnema
	Hindwings with 4 and 5 widely separate	4
4.	Hindwings with a strong costal tuft	Euthesaura
	Hindwings without costal tuft	5
5.	Labial palpi extremely long (8), maxiliary palpi strongly dilated	Tineodes
	Labial palpi moderately long (4), maxillary palpi filiform	Euthrausta

Gen. **Anomima**, nov.

Palpi long (about 4), porrect; terminal joint short, acute. Maxillary palpi moderately long. Antennae in ♂ serrate and shortly ciliated. Thorax and abdomen moderately stout. Legs moderately long; tibial spurs nearly equal. Forewings with 2 and 3 long-stalked from angle, 4, 5 separate, 6 widely separate, 7 connate with 8, 9, 10, which are stalked, 8 arising shortly before 10, 11 from $\frac{2}{3}$. Hindwings with 2, 3, 4, 5 remote, equidistant, parallel, 2 arising from before angle, 6 and 7 connate from upper angle, 7 approximated to 8 for a short distance, but not anastomosing.

The solitary example on which this genus is based was captured some thirty years ago, and is in bad condition, the head somewhat mutilated, so that I am not able to give the characters fully, but sufficiently so to indicate that it is a very distinct genus. The absence of any anastomosis of 7 of the hindwings and the generally stout build are primitive characters, but the neuration of the forewings is specialised, and the origin of 6 of hindwings is a later

character than its separate origin. It is probably derived from the Indian genus *Simaethistis*.

ANOMIMA PHAEOCHROA, n.sp.

♂ 18 mm. Head, thorax, and abdomen fuscous. Palpi 4, fuscous. Antennae fuscous. Legs pale-fuscous with darker irroration. Forewings elongate-triangular, costa nearly straight, apex round-pointed, termen concave, slightly oblique; pale-fuscous irrorated throughout with darker scales; a small, round, dark-fuscous, discal spot at end of cell beneath midcosta; a subterminal series of dark-fuscous dots; cilia fuscous. Hindwings narrow, subtriangular, apex round-pointed, termen sinuate; as forewings, but without markings.

The type is in poor condition, but amply distinguished by the generic characters. At best this must be a dull-coloured inconspicuous insect.

Q., Brisbane; one specimen.

Gen. Palaeodes.

Palaeodes, Hmps., A.M.N.H. (8), xii., p. 318 (1913).

Frons flat. Tongue present. Palpi long (4), porrect; second joint thickened with short rough hairs above and beneath, with a slight apical inferior tuft; terminal joint short, slender, acute. Maxillary palpi rather large, rough-scaled, strongly dilated. Antennae simple except towards apex, where apices of joints are slightly dilated by whorls of scales; in ♂ shortly ciliated throughout. Thorax and abdomen rather slender, smooth. Posterior tibiae with spurs nearly equal. Forewings with 2 from shortly before angle, 3, 4, 5 approximated from about angle, 6 separate, 7, 8, 9, 10 approximated, 11 from $\frac{4}{5}$. Hindwings with 2 from $\frac{3}{4}$, 3, 4 connate from angle, 5 widely separate from middle of cell. 6, 7 connate, 7 anastomosing with 8. Retinaculum in ♂ not bar-shaped.

The absence of stalking of 8 and 9 of forewings distinguishes this genus.

PALAEODES SAMEALIS.

Palaeodes samealis, Hmps., A.M.N.H. (8), xii., p. 318 (1913).

N.Q., Herberton, Townsville. Q., Coolangatta, Toowoomba.

Gen. Tanycnema, nov.

Frons with a strong anterior tuft of hairs. Tongue present. Palpi rather long, porrect. Maxillary palpi obsolete. Antennae short. Legs long, slender; outer tibial spurs about $\frac{3}{4}$ length of inner spurs. Forewings narrow, elongate; 2 from well before angle, 3 from angle, 4 and 5 somewhat approximate at origin, 6 from upper angle, 7, 8, 9, 10 stalked, 7 arising slightly before 10, 11 free. Hindwings twice as broad as forewings; 2 from $\frac{3}{4}$, 3 from angle, 4 and 5 somewhat approximate at origin, 6 well separated at origin from 5, still more widely from 7, 7 from upper angle, closely approximated to 12 for some distance, but not anastomosing.

A peculiar, isolated, and primitive genus. The wide separation of 6 from 7 of the hindwings, and the absence of any anastomosis of 7 with 12 are primitive characters; on the other hand the relative approximation of 5 to 4 in the hindwings, and the stalking of 7 and 10 of the forewings are specialised characters, the former being unique in this family, to which the genus must, I think, be referred, though the absence of maxillary palpi (if confirmed), suggests some relationship to the *Pterophoridae*, but this may be more apparent than real.

TANYCNEMA ANOMALA, n. sp.

♂ 34 mm. Head and thorax brownish-grey. Palpi $3\frac{1}{2}$; brownish. Antennae about $\frac{1}{2}$; fuscous. Abdomen grey; dorsum of basal segment whitish-grey. Legs brownish-grey. Forewings narrow, elongate, gradually dilating posteriorly, but only to a moderate extent, costa straight to middle, thence sinuate, apex pointed, termen slightly sinuate, slightly oblique; brownish-grey; costa broadly suffused with ochreous-whitish throughout; an ochreous-whitish dot at $\frac{2}{3}$ on end of cell; a suffused inwardly-oblique, fuscous streak from before apex, cutting across pale costal area, then slightly dentate to about halfway across disc; a whitish subterminal line from apical pale area to vein 3; a similar line precedes terminal edge, which is fuscous, and is itself preceded by an obscure series of fuscous dots; cilia whitish-brown. Hindwings with apex tolerably pointed, termen gently rounded, wavy; grey; cilia grey.

Q., National Park (3000 ft.), in December; one specimen.

Gen. Euthesaura, nov.

Frons flat. Tongue present. Palpi moderate (not exceeding 2), porrect; second joint thickened with rough hairs; terminal joint very short. Maxillary palpi short, filiform. Antennae over 1, slender, joints dilated by whorls of short scales at apices; in ♂ without ciliations. Thorax and abdomen slender; inner tibial spurs twice as long as outer. Forewings with 2 from well before angle, 3 from angle, 4 from shortly above, 5 and 6 widely separate, 7 approximated to 8, 9, which are stalked from angle, 10 approximated to them at origin, 11 from middle of cell. Hindwings with a strong tuft of scales on costa beyond middle; 2 from $\frac{2}{3}$, 3 and 4 approximated from angle, 5 parallel from middle of cell, 6 widely separate, 7 from angle anastomosing shortly with 8. Retinaculum in ♂ bar-shaped.

Distinguished by the comparatively short labial palpi, and short filiform maxillary palpi, costal tuft of hindwings, and very unequal tibial spurs. Type *E. glycina.*

EUTHESAURA GLYCINA, n. sp.

♂ 18-20 mm. Head and thorax fuscous. Palpi about 2; fuscous, lower edge ochreous. Antennae grey. Abdomen whitish; two basal segments and some median dorsal dots dark-fuscous. Legs ochreous-whitish; anterior pair mostly fuscous. Forewings elongate-triangular; costa bisinuate, apex acute, termen nearly straight, oblique;

white with patchy dark-fuscous suffusion in parts; a large basal patch prolonged along costa to beyond middle; a spot on mid-dorsum tending to be connected with costa by scattered dark scales; another dorsal spot at $\frac{3}{4}$; a large tornal spot suffusedly connected with another before termen above middle, and this with costa; a large, transversely-elongate, ochreous, fuscous-edged mark in disc beneath $\frac{2}{3}$ costa; an interrupted, dark-fuscous line on upper half of termen; cilia whitish. Hindwings with costa slightly concave, with strong tufts of scales before and after excavation, apex rounded-rectangular, termen sinuate; white, an elongate blackish spot on base of dorsum; a broadly suffused ante-median, transverse, fuscous fascia, broader towards costa, where it contains an ochreous black-edged spot; a second fuscous fascia from tuft on $\frac{2}{3}$ costa to tornus; terminal dots and cilia as forewings.

Q., National Park (3000 ft.), in December and January; twelve specimens, all of the same sex.

EUTHESAURA CARBONARIA, n. sp.

♂ ♀ 19-21 mm. Head blackish. Palpi 1; blackish. Antennae about 1; grey, towards base blackish. Thorax and abdomen blackish. Legs dark fuscous; tarsi barred with whitish on upper surface, wholly whitish beneath. Forewings narrow to beyond middle, very strongly dilated towards termen, costa bisinuate, apex pointed, termen scarcely bowed, oblique, dark-fuscous; markings blackish; an outwardly bent, sub-basal, transverse line; a broad line from $\frac{1}{3}$ costa, strongly angled outwards, not reaching dorsum; a suffused whitish subcostal streak, broadening posteriorly, from second line to discal spot; discal spot at $\frac{2}{3}$ narrowly oval, transverse brownish-tinged in centre, posteriorly narrowly edged with whitish; connected by a sinuate line with $\frac{2}{3}$ dorsum; four, minute, whitish, nearly equidistant dots on apical third of costa; from beneath the first of these is a third transverse line to dorsum before tornus; from the second a fourth curved subterminal line to tornus; cilia dark-fuscous, with a narrow whitish basal line from apex to midtermen. Hindwings very strongly dilated beyond middle, with a strong tuft of scales on $\frac{2}{3}$ costa, apex rounded, termen sinuate; as forewings but without discal spot; one or two variable whitish dots on or near second line.

Q., National Park (3000 ft.), in December and January; seven specimens, 5 ♂ 2 ♀.

Gen. **Tineodes.**

Tineodes Gn., Lep. viii., p. 236, Meyr., Tr. E.S., 1884, p. 291. Hmps., P.Z.S., 1899, p. 284.

Frons flat. Tongue present. Palpi extremely elongate (about 8), porrect; second joint thickened with short rough hairs above and beneath; with a slight apical inferior tuft; terminal joint short, smooth, pointed. Maxillary palpi rather large, rough-scaled, strongly dilated. Antennae 1, slender, joints dilated by whorls of raised scales at apices. Thorax and abdomen slender, smooth. Legs very long and slender, inner spurs slightly longer than outer. Forewings with 2 from well

before angle, 3 from angle, 4 from shortly above, 5 and 6 widely separate, 7 closely approximated at origin to 8, 9, which are stalked, 10 closely approximated, 11 from $\frac{3}{4}$. Hindwings with 2 to 7 equidistant and parallel, 2 arising from before angle, 7 anastomosing shortly with 8 soon after origin.

Specially characterised by the extremely long palpi. Sir George Hampson (*loc. cit.*) has incorrectly described the neuration of the hindwings.

TINEODES ADACTYLALIS.

Tineodes adactylalis Gn., Lep. viii., p. 237, Pl. 9, f. 7., Meyr. Tr. E.S., 1884, p. 291.

Carcantia pterophoralis, Wlk., Cat. Brit. Mus., xvii., 425.

Q., Coolangatta; N.S.W., Sydney; V., Gisborne; W.A., Waroona.

Gen. **Euthrausta**, nov.

Frons with anterior tuft of hairs. Tongue present. Palpi moderately long (3 to 4), porrect or slightly depressed; second joint dilated with rough scales above and beneath; terminal joint minute, almost concealed. Maxillary palpi moderate, filiform. Antennae over 1, slender, joints dilated by whorls of raised scales at apices; in ♂ with long ciliations on basal part, apical part not ciliated. Thorax and abdomen slender, not crested. Legs very long and slender, inner spurs slightly longer than outer. Forewings with 2 from $\frac{2}{3}$, 3 from before angle, 3, 4, 5, 6 equidistant and parallel, 7 approximated at origin to 8, 9, which are stalked, 10 approximated, 11 from middle. Hindwings with 2 from middle, 3 from before angle, 3, 4, 5, 6, 7 equidistant and parallel, 7 anastomosing with 8. Rectinaculum of ♂ short, bar-shaped. Type, *E. oxyprora*.

EUTHRAUSTA PHOENICEA.

Tineodes phoenicea Turn., Tr. R.S., S.A., 1908, p. 107.

N.Q., Herberton; Q., Brisbane.

EUTHRAUSTA OXYPRORA.

Tineodes oxyprora Turn., Tr. R.S., S.A. 1908, p. 108.

N.Q., Cairns; Q., Brisbane.

EUTHRAUSTA HOLOPHAEA.

Tineodes holophaea Turn., Tr. R.S., S.A., 1908, p. 108.

That this is not an aberration of the preceding is shown by the much shorter antennae ciliations of the ♂.

N.Q., Cairns.

Fam. AEGERIADAE.

In the Proc. Roy. Soc. Q., 1917, p. 78, I attempted a revision of the few known Australian species of this family, not knowing that Le Cerf was publishing at the same time an important paper on this family in Oberthur's Etudes de Lepidopterologie Comparee, xiv., p. 127. Since then Sir Geo. Hampson has completed a revision of the

Oriental species in the Novitates Zool., 1919, p. 46, which contains several species not known to me. It seems advisable, therefore, to give a fresh synopsis of the known Australian species,* of which there are now fifteen, all (except one introduced form) from Queensland and North Australia, and to give a tabulation of the genera.

1. Antennae dilated towards apex and ending in a minute tuft of hairs 2
   Antennae not so formed 5
2. Hindwings with 3 from angle of cell connate or stalked with 4, 5 3
   Hindwings with 3 separate from before angle 4
3. Posterior tarsi with first joint fringed with scales above Lepidopoda
   Posterior tarsi without fringe of scales above . . . . Trochilium
4. Hindwings with 3 arising from as near or nearer 2 than 5 . . . . Melittia
   Hindwings with 3 arising from nearer 5 than 2 . . . Paranthrene
5. Hindwings with 3 and 5 stalked 6
   Hindwings with 3 arising remote from 5 . . . . Tinthia
6. ♂ without tongue, and with dense tufts of hair on middle and posterior tibiae . . . . Lophocnema
   ♂ with tongue, and without tibial tufts . . . . Diapyra

Gen. Lepidopoda.

Lepidopoda, Hmps., J. Bomb. Nat. Hist. Soc., 1900, p. 43, Type, *L. heterogyna* Hmps., from India.

Lepidopoda xanthogyna.

Lepidopoda xanthogyna, Hmps., Nov. Zool., 1919, p. 54. N.Q., Cairns.

Gen. Trochilium.

Trochilium, Scop., Int. Nat. Hist., p. 414 (1777).

Trochilium chrysophanes.

Sesia chrysophanes, Meyr., P.L.S., N.S.W., 1886, p. 689.
♂ *Aegeria panyasis*, Druce, A.M.N.H., (7), p. 201 (1899).
♀ *Aegeria caieta*, Druce, *ibid*, p. 202.

The latter is the southern form; it differs only in the orange markings of the ♀ being replaced by yellow; the ♂ differs much less. I cannot regard it as more than a local race. Mr. Dodd has bred the species from *Alphitonia excelsa*.

N.Q., Townsville, Bowen; Q., Brisbane, Mt. Tambourine, Toowoomba.

Trochilium melanocerum.

Conopia melanocera, Hmps., Nov. Zool., 1919, p. 71.
N.Q., Cairns, Innisfail.

Trochilium tipuliforme.

Sesia tipuliformis, Clerck, Icones, Pl. 4, f. 1 (1759).

Tasmania; two specimens received from Mr. G. H. Hardy. This is an introduced species feeding on the currant (especially *Ribes*

nigrum), which has been introduced from Europe to America, New Zealand and Australia.

TROCHILIUM CORACODES, n. sp.

♂ ♀ 28–30 mm. Head black; sides of face white. Palpi 3, upturned, second joint rough-scaled, terminal joint ½, smooth; black, in second joint mixed with white scales anteriorly. Antennae black; basal joint, with an anterior white spot; in ♂ slightly serrate with tufts of cilia, cilia ⅔. Thorax, abdomen and tuft black, with bluish reflections, abdomen with a few whitish scales. Forewings spathulate; black with lustrous bluish scales in disc; a narrow hyaline streak in cell, and another beneath cell towards base; cilia blackish. Hindwings with termen gently rounded; 3 and 5 connate; hyaline; all veins, a spot on end of cell, and a narrow marginal line on termen and dorsum, black; cilia blackish. Underside similar.

Q., Toowoomba, in February; two specimens taken together by Mr. W. B. Barnard, who has kindly given me the type.

Gen. **Melittia.**

Melittia, Hb., Verz., p. 128.

Type, *M. bombyliformis*, Cram., from India.

MELITTIA AMBOINENSIS.

Melittia amboinensis, Feld., Sitz. Akad. Wiess. Wien, 1861, p. 28.

Melittia amboinensis, var. *doddi*, Le Cerf, Obert. Et. Lep. Comp. xii. i., Pl. 373, f. 3119-3120 (1916), ibid. xiv., p. 1916.

Melittia thaumasia, Turn., P.R.S.Q., 1917, p. 81.

N.Q., Claudie River, Cairns. Also from the Archipelago and India.

MELITTIA CHALYBESCENS.

Melittia chalybescens, Misk., P.R.S., Q., 1892, p. 59.

N.Q.,

MELITTIA PROSERPINA.

Melittia proserpina, Hmps., Nov. Zool., 1919, p. 92.

N.Q., Claudie River, Cairns.

Gen. **Paranthrene.**

Paranthrene, Hb., Verz., p. 128.

Type, *P. tabaniformis*, Rott., from Europe.

PARANTHRENE OBERTHURI.

Phlogothauma oberthuri, Le Cerf, Oberth. Et. Lep. Comp. xii. i. Pl. 376, f. 3141-3142 (1916), *ibid.* xiv. p. 251.

Sciapteron terribile, Turn., P.R.S., Q., 1917, p. 81.

N.A., Port Darwin, Melville Island.

**Balataea hemotona*, Swin., Cat. Oxf. Mus., p. 86, belongs to the genus Miscera (Glyphipterygidae).

PARANTHRENE ISOZONA.

Sesia isozona, Meyr., P.L.S., N.S.W., 1886, p. 689.

Q., Maryborough.

PARANTHRENE CAERULIFERA.

Paranthrene carulifera (misprint), Hmps., Nov. Zool., 1919, p. 108.

N.Q., Cairns.

PARANTHRENE ZONIOTA, n. sp.

♂ 24 mm. Head with crown blackish; face whitish. Palpi whitish; extreme base and terminal joint dark-fuscous. Antennae fuscous, towards base brownish; in ♂ simple. Thorax blackish; patagia dark-grey. Abdomen blackish; a white ring on apex of fifth segment; apices of following segments whitish on under-surface; tuft blackish. Legs fuscous; anterior coxae whitish. Forewings narrow, posteriorly dilated, costa straight to near apex, apex round-pointed, termen obliquely rounded; hyaline; veins, a broad transverse bar at end of cell, and a terminal band dark-fuscous with purple reflections; cilia dark-fuscous. Hindwings over 2; hyaline; veins, a broad transverse bar at end of cell, and a narrow terminal band lessening towards tornus dark-fuscous.

Type in National Museum, Melbourne.

N.Q., Claudie River, in January; one specimen taken by Mr. J. A. Kershaw.

Gen. Lophocnema.

Lophocnema, Turn., P.R.S., Q., 1917, p. 78.

Type, *L. eusphyra*, Turn.

LOPHOCNEMA EUSPHYRA.

Lophocnema eusphyra, Turn., P.R.S., Q., 1917, p. 79.

N.Q., Cairns.

Gen. Diapyra.

Diapyra, Turn., P.R.S., Q., 1917, p. 79.

Glossecia, Hmps., Nov. Zool., 1919, p. 113.

Type, *D. igniflua*, Luc.

DIAPYRA IGNIFLUA.

Sesia igniflua Luc., P.L.S., N.S.W., 1893, p. 133.

Diapyra igniflua, Turn., P.R.S., Q., 1917, p. 79.

Q., Brisbane.

Gen. Tinthia.

Tinthia, Wlk., Cat. Brit. Mus., xxxi., p. 23.

Type, *T. varipes*, Wlk., from Celebes.

TINTHIA XANTHOSPILA.

Tinthia xanthospila, Hmps., Nov. Zool., 1919, p. 115.

N.Q., Cooktown.

[Proc. Roy. Soc. Victoria, 35 (N.S.), Pt. I., 1922].

Art. V.—*On the Drying of Timber.*

By REUBEN T. PATTON, B.Sc., M.F.

(With 9 Text Figures.)

[Read 8th June, 1922.]

The drying of timber is governed by six factors, namely, Moisture Content, Diffusion of Moisture, Evaporating Surface, Thickness, Humidity and Temperature. The first two may be conveniently referred to as the biological factors since they are due to the plant's activity, and are quite beyond our control. The last two may be referred to as the mechanical factors, since we can vary them at will. The two intermediate factors, Evaporating Surface and Thickness, belong partly to both. We may cut a piece of timber to any thickness, or so as to expose more or less of one face than another, but having so cut it, its drying will be governed by the organization of the wood substance.

The work contained herein was commenced at Melbourne (Victoria) and was subsequently carried on at London. The work had its origin in the difference of opinion which exists as to the relative merits of air and kiln-drying of timber. The research had for its object a study of all the factors influencing the drying of timber, in order to ascertain what is involved in the phenomenon of seasoning. It may be here remarked that the term kiln seasoning involves widely different ideas and practices. In some kilns, wholly artificial conditions are used, the temperatures used, for instance, being far in excess of any found in nature. On the other hand, some kiln drying is carried on at about the maximum atmospheric temperatures. In this latter case, it is the continuance of the temperature, not the temperature itself, that is artificial. Timber in our State may be subject to a temperature of 123.5F, and at Melbourne itself to a temperature of 111°F.

There is no doubt in the mind of the wood worker as to the value of air-seasoned timber. Up to the present generation, all the finest wood work of the world has been carried out with air-seasoned timber. That is, in itself, quite a sufficient answer to the statements sometimes made that air-dried timber is inferior to kiln dried. However, modern civilisation demands a greater supply of seasoned timber than can be met by the old practice of air drying. The first aim, therefore, was a study of drying under conditions which have produced such satisfactory results in the past. The work, therefore, was carried on at such temperatures and humidities which, with slight exceptions, are found in nature.

Moisture Content.—In the seasoning of timber we are concerned not only with how much moisture there may be in the wood of a tree when it is felled, but also how that moisture is distributed in the tree, and also whether the moisture content is a constant all through

the year. In other words, we are concerned with the quantity of moisture and its distribution both in space and time.

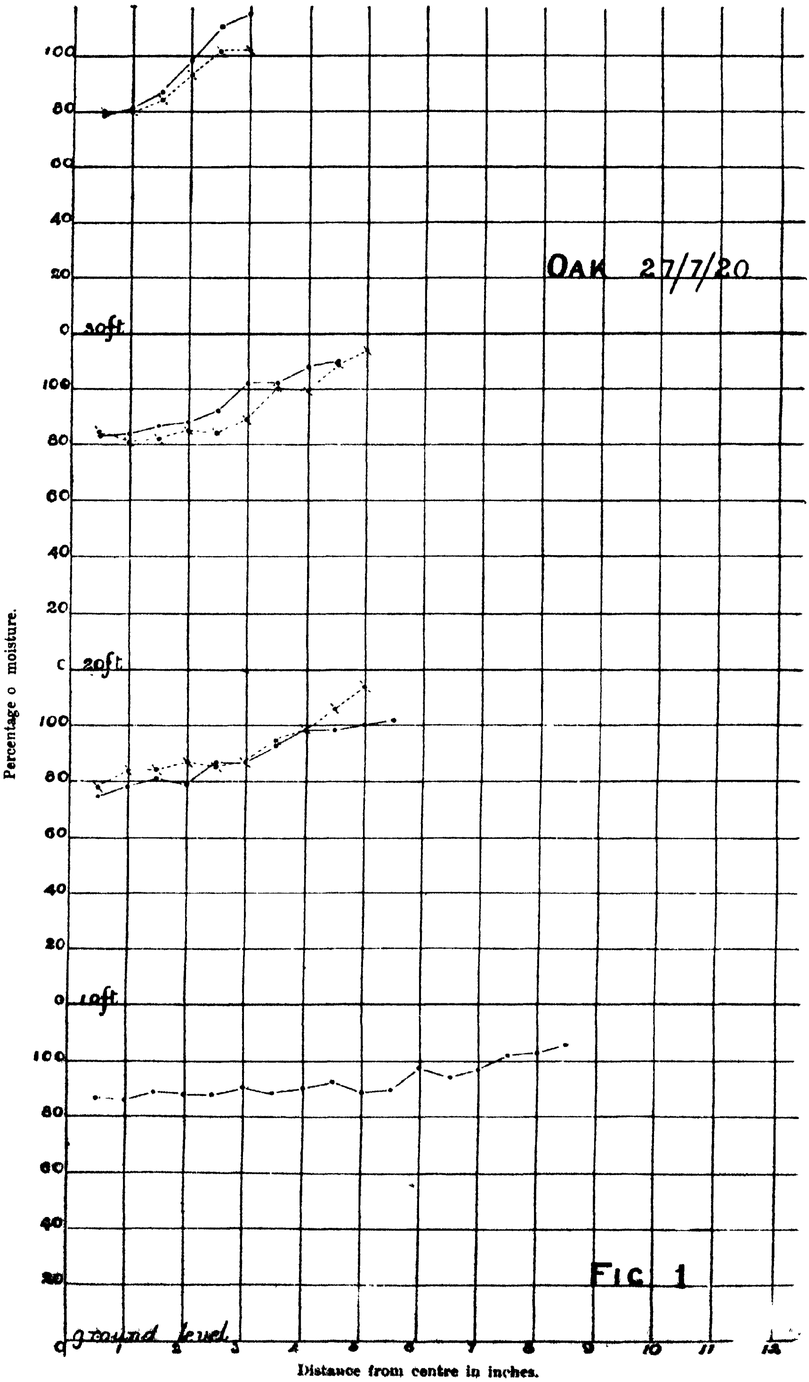
If the sapwood be the means by which water is transported in a living tree, then it should not matter at what time of the year a tree is felled, and if the heartwood be inactive, then we should expect the heartwood content to be a constant. It is obvious, however, that if the heartwood content does undergo a seasonal change, then there is a favourable period for felling. Ordinarily, however, when we speak of the sap as rising, we are considering only the sapwood, and not the heartwood.

It has recently been suggested(1) that the heartwood may play an important part in the moisture needs of the plant. It is suggested that the heartwood acts as a reservoir for the sapwood. This may be true for some trees, but it cannot hold for all. The giant eucalypt of Victoria, *E. regnans*, may have practically no heartwood at all, as it may have all rotted away, yet the tree may live for centuries. The trunk is a mere shell, yet the needs of the tree are met. It was quite a well-known belief among the tree-fellers in the Victorian forests that the central portion of the heartwood of our big trees contained more moisture than the outer portion of the heartwood. In many cases it was found that this central portion contained more moisture than the sapwood. This central portion is very prone to decay, and is rejected in timber milling. An examination of it microscopically shows that the fibres have comparatively thin walls. The percentages of moisture for one tree were as follow:—

Central portion	150 per cent.
Outer heartwood	77 per cent.
Sapwood	110 per cent.

The percentages are calculated to the dry weight of the wood.

The differential distribution of moisture in *Acer pseudoplatanus* was fully investigated at Edinburgh(1). The investigation was carried on during the dormant period of the tree, i.e., from October to March. The matter was further studied at London during 1920, and the results are given herein. The period of investigation was from February to September, that is, from the end of the winter to the beginning of the autumn. The trees selected for the main investigation were oaks (*Quercus robur*). In every case they were felled in the morning and cross sections, two inches thick, were taken every 10 feet. These sections were at once wrapped in grease paper and taken to the laboratory, where a strip one and a-half inches wide was cut from the centre to the bark. These strips were then split into half-inch pieces, commencing at the centre. If there was an odd width left at the sapwood end, this was considered as a half-inch, and is graphed accordingly. The small pieces were at once weighed and then dried. The percentage of moisture is calculated to the dry weight of wood. In some cases two strips were taken from the section, and these are given on the graphs. In Fig. 1 is given a typical moisture distribution in oak. The first tree was felled on March 2nd, 1920, and the last tree on September 1st. All the trees were taken from the same area and soil which was heavy clay.



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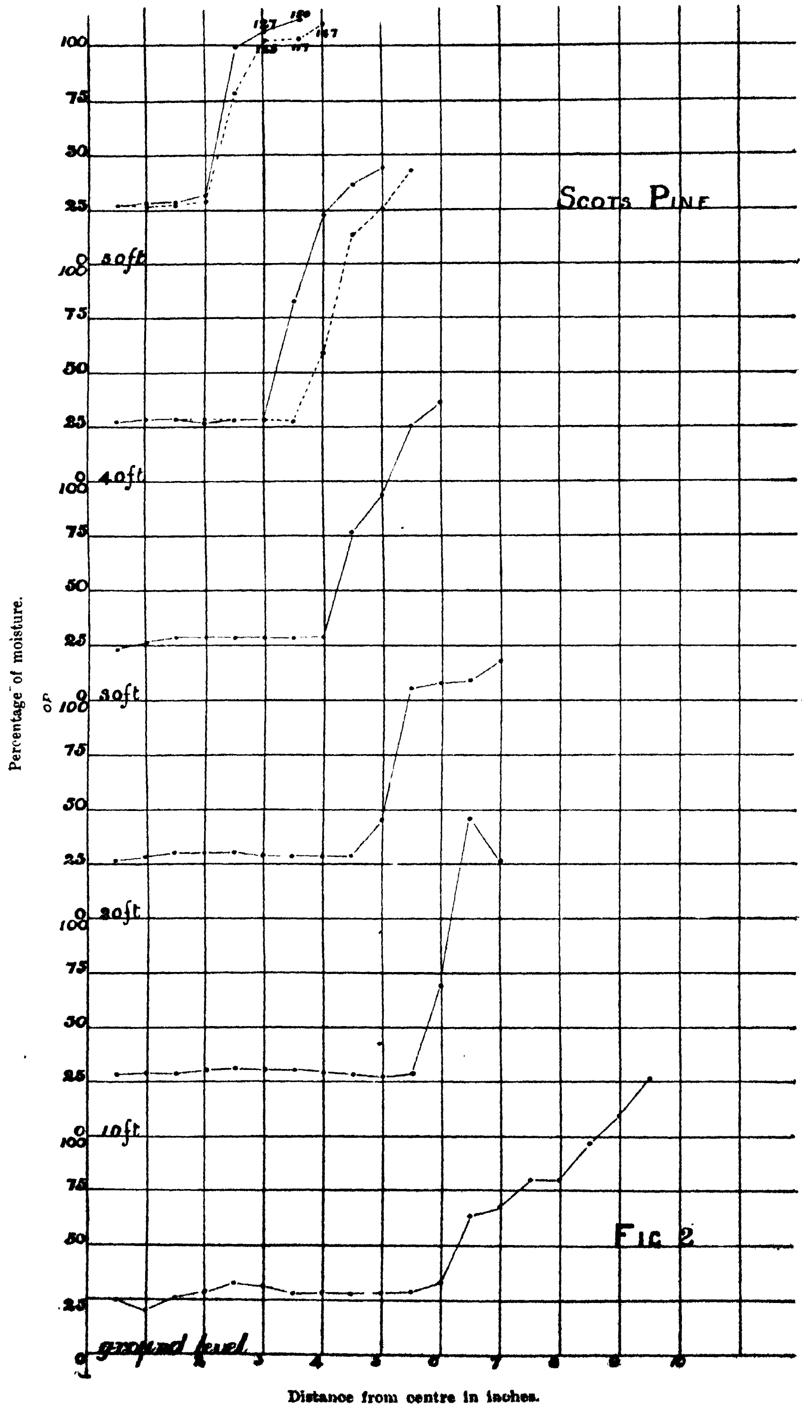
DISTRIBUTION OF MOISTURE IN THE TRUNK OF OAK.


Scots Pine
50 ft
40 ft
30 ft
20 ft
10 ft
ground level
Fig 2
Percentage of moisture.
Distance from centre in inches.

Owing to financial considerations, it has been found impossible to publish all the graphs, but Fig. 1 is typical of the series. In the graphs for the first trees felled there was a tendency for the curves to sink downwards in the sapwood area, but there was nothing definite, however. When the first tree was felled, there was no sign of the bursting of the buds. On the 23rd March, when the second tree was felled some of the buds appeared as if they were commencing to swell, but there was no further indication of bursting when the third tree was felled on April 22nd. In the graphs for these three trees, the curves rise steadily from the centre of the tree to the outer portion of the heartwood, just as is the case in Fig. 1.

The fourth tree was felled on June 2nd and the fifth on July 27th. Both these trees were in full leaf, and transpiration was greatest. The last tree was felled on September 1st. The oaks were still green, but some of the other trees were showing signs of autumn. The lime (*Tilia Europoea*) was well advanced with its autumn tints. The graph for the last tree did not differ materially from that given. Taking the graphs as a whole, it would appear that the moisture content of the heartwood is constant. There is, however, a well marked rise from the centre to the sapwood.

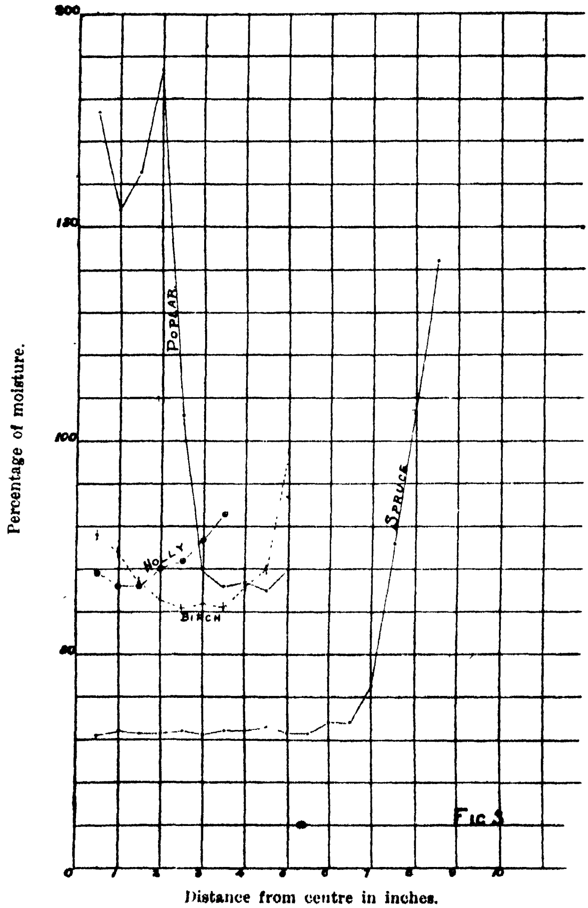
In Fig. 2 is given the moisture distribution of Scots Pine (*Pinus sylvestris*). The tree was a very fine specimen, and was growing in a pure stand of pine. It was felled on February 25th. It will be seen that the moisture content of the heartwood is very low as compared with that of the sapwood. The difference between the moisture content of heartwood and sapwood of oak is small. In pine, the moisture content of the heartwood is very low as compared with that of oak, while the content of the sapwood of the pine is much higher than that of oak. A low moisture content of the heartwood appears to be characteristic of conifers generally. The moisture distribution is not only very low in the heartwood, but it is very evenly distributed. There is no steady rise from the centre to the sapwood. The vertical distribution is also very uniform. From the practical standpoint, the heartwood of pine is easy to dry owing to the small and even distribution of the moisture.

In Fig. 3 are given the graphs of the moisture distribution of several trees. With the exception of spruce, the sections were taken at breast high. All these trees were growing in the same forest from which the oaks were obtained. The spruce (*Picea excelsa*) was a very fine specimen. It was felled on April 22nd, and the section was taken just above ground level. The graph conforms to those of the pine. There is the same low heartwood content and extremely high sapwood content. The poplar (*Populus nigra*) was a fine tree, and was felled on April 22nd. The distribution of the moisture was extraordinary.

The birch (*Betula alba*) was felled on March 25th. It also has a peculiar moisture distribution. The holly (*Ilex aquifolium*) was felled on August 5th. The graphs in Fig. 3 show that the lateral moisture distributon in trees requires investigation. Such varying distributions of moisture may very seriously affect the drying of lumber,

especially if the drying is uneven, due to circulation of the air being bad.

So far as the graphs for oak and pine are concerned, it would appear that it does not matter when the trees are felled. There does not appear to be any movement of the moisture in the heartwood of oak, and it is inconceivable that the heartwood of pine can ever contain a great amount of moisture to meet the needs of the tree.



LATERAL DISTRIBUTION OF MOISTURE IN VARIOUS TREES.

As already mentioned, the big trees of Victoria frequently have very little heartwood, as it has rotted away.

Diffusion.—The second biological factor is that of the power of any particular timber to lose its moisture. When it is said that a wood is difficult to season, all that is meant is that the wood loses its moisture either too slowly or too quickly. If it loses the moisture

too rapidly, then the wood is very apt to warp, especially if the drying be at all uneven. This appears to be the case with elm (*Ulmus campestris*). On the other hand, if the moisture be lost very slowly, any attempt to hurry up the drying will lead either to warping or cracking, as in the case of oak, where the medullary rays tend to open out. Wood that contains a low percentage of moisture is not difficult to season.

We have already seen that different species contain different amounts of moisture. Hence we cannot compare their rates of drying. However, moisture is lost by diffusion, and we know from the laws of diffusion that the amount of moisture lost is proportional to the gradient of the concentration, and the area of the evaporating surface. It is expressed mathematically as—

$$dx/dt = \mathrm{D}d\,\mathrm{C.A}/dl.$$

Where for timber x is amount of moisture lost in grams, t is time in days, c is concentration of the moisture, l is length in inches, A is area of diffusing surface in sq. inches, and D is the diffusion constant.

The amount of moisture diffused will also be affected by Temperature and Humidity, but these may be omitted if the conditions are kept constant.

If this formula can be applied to the drying of wood, then the value of D will give us a measure of the ease or difficulty with which any particular timber parts with its moisture. Owing to the many difficulties in applying such a formula to timber drying, it was not expected to obtain any very accurate results. In fact, accuracy is impossible. But what might be expected is that values would be obtained which would give an indication of the relative powers of diffusion of the various timbers. For the experimental work, blocks of straight grained, freshly felled timber were cut into sizes approximately 2 x 2 x 3 inches. The 2 x 2 face was tangential and the length, 3 inches, was in a radial direction. The four 2″ x 3″ sides were coated with the mixture recommended by Tiemann (2). The blocks were placed in an oven at 40°C. and at a 50 per cent. humidity. They were weighed at the same time every day, and the loss of weight plotted so that any irregularity of loss might be noticed. While the blocks were still actively drying, the sides were cut off and the blocks split up into one quarter of an inch sections. These sections were at once weighed and then dried, and the moisture percentage calculated to the dry weight. These percentages were plotted as in fig. 4, and the moisture gradient was obtained by drawing a tangent at the extremity of the curve. The value of the gradient was substituted in the equation for dC/dl. Half of the amount lost in the previous 24 hours was taken as the value of dx/dt.

The value of D obtained from the formula is by no means accurate, as the values obtained are somewhat wide. This was expected for various reasons. The width of ring varies greatly, even in the same specimen, and may even vary widely in two adjacent rings. In a pile of Red Oak (*Quercus rubra*) which was ready to go into a kiln the width of ring varied from one-half to one-tenth of an inch.

The material was inch timber, and quite a number of the boards had only two rings of growth. It may reasonably be expected that there would be, in such timber, a great variation in the rate of diffusion. No material could be obtained, however, to investigate this matter.

In Table I. are given the results of the calculations for D. for various timbers at 40°C. and 50 per cent. humidity.

TABLE I

Timber	Botanical Name	Values of D						Average
Oak	*Quercus robur*	.0012	.0026	.0032	.0048	.0056	0057	.0038
Birch	*Betula alba*	.0049	.0067		—	—	—	.0058
Beech	*Fagus sylvatica*	.0061	.0072	.0092	.0113	.0142	.0169	.0108
Elm	*Ulmus campestris*	.0084	.0102	.0169	—	—	—	.0118
Scots Pine	*Pinus sylvestris*	.0051	.0115	.0195	.0240	.0266	—	.0173

The average values of Oak, Beech and Pine generally indicate the positions of these timbers as regards drying in practice. Both Elm and Beech are said to be difficult to dry, as they warp badly while drying. Both Beech and Elm have a high moisture content, and as we have found a high diffusion constant. These timbers lose moisture rapidly, and unless the drying be uniform warping will result. The cause of the warping of Elm is said to be due to its twisted grain, but an examination of a large amount of elm lumber does not bear this out. It is true that twisted grain will produce warping, and this is freely borne out by such a timber as River Red Gum (*Eucalyptus rostrata*). It is doubtful if any other timber even approaches this for irregularity of grain. A twisted grain, however, does not appear to be a character of the elms. The warping of elm is most likely to be due to uneven drying.

In Victoria our timbers warp a great amount due to bad stacking. The green sawn timber is frequently stacked in a mass, and no provision is made for circulation of air through the pile. The stack is exposed to the fierce rays of the summer sun, and the top timber warps badly in consequence. The pieces of timber in the interior of the stack can only dry by their exposed ends, and these crack badly. All kinds of timber are stacked out in the open in Eastern U.S.A., but the stack is properly ventilated. There is a space between each board laterally and vertically. The top of the stack is roofed with off cuts from the logs. The timber comes out of these stacks in perfect condition.

Oak is difficult to dry because it has a high moisture content and a low power of diffusion. Pine, on the other hand, has a low moisture content, but a high power of diffusion, hence drying is rapid.

If we knew the moisture content of a species of timber and its diffusion constant, we might then be able to predict the time necessary

for drying, and we could, if kiln drying, prescribe the necessary treatment. Until we know more about the diffusion of moisture in wood, formulas for drying are more or less guesswork.

In general the diffusion constant will vary with the specific gravity of timber. Dense heavy timbers are generally slow in drying, and therefore we may expect a low diffusion constant. The cell walls in conifers are on the whole much thinner than the walls of the fibres of hardwoods. The walls of the tracheides are comparable to the walls of the vessels.

Tissues, engaged in water conduction, must have relatively thin walls. Water conducting elements have their walls freely pitted, while strength elements such as the libriform fibres are sparsely pitted. Coniferous timber has a higher power of diffusion than most dicotyledonous timbers, because the elements concerned in drying, the tracheides, are the water conducting elements, while in the hardwoods the elements concerned in drying are the fibres or strength elements. The movement of water in a tree is, in some intimate way, closely associated with the cell walls, and if a hardwood consisted of vessels only, we should find this timber drying as quickly as coniferous.

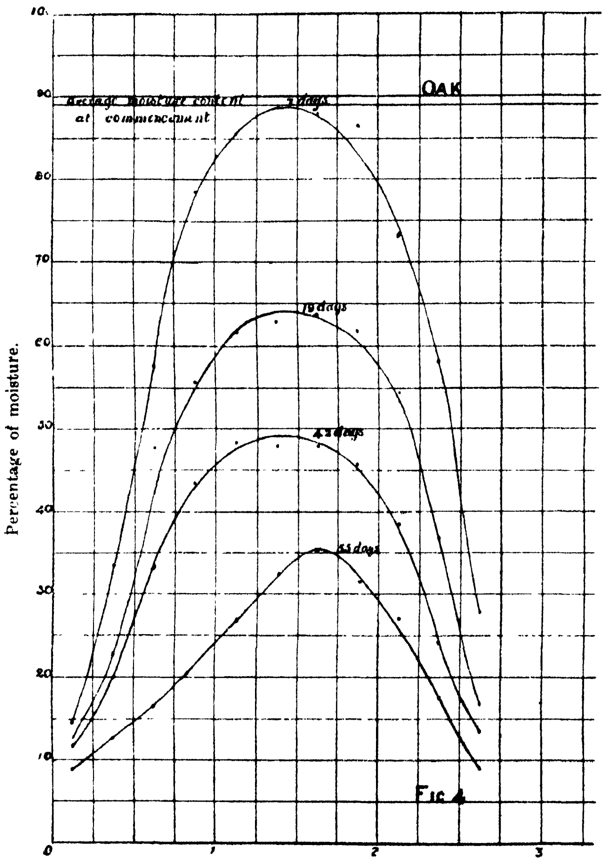
It is of interest to know how the moisture diffuses through the wood. Moisture in wood has been classified into free water and water of saturation. All water in the timber over or above what is known as the fibre saturation point, is called free water. The fibre saturation point is defined as the concentration of water necessary to saturate the walls of the cells without there being any water in the cavities of the cells. The term free water is used because it is assumed that this so-called free water passes out of the wood first when timber is drying. When it has all been lost the timber is then at the fibre saturation point. When the water of saturation begins to be lost, shrinkage begins.

This theory of the loss of moisture from wood is against the facts.

The word "free" is unfortunate, as the term implies that the water is free to move. Now if a block of wood containing this so-called water be placed in a saturated atmosphere, the block remains constant in weight. In soils we get free water, which is the water in excess of saturation. The water is truly free, because it moves under the force of gravity. The water in the cells of the wood is not free to move under the force of gravity. Instead of calling this cell water free, we may call it *Contained Water*. There is, however, actual free water in a tree. When a giant eucalypt is felled, water pours from the cut end of the bole. This may be observed even in mid-summer. This water is truly free, for we cannot prevent its loss by merely altering the humidity of the atmosphere.

Free water occurs in birch, and the phenomenon of weeping is well known. This free water has all been lost by the time the logs get to the mill. We may define Free Water as the water which escapes from the lumber not as vapor, but as a liquid. The loss is due to the force of gravity. Free water, as here defined, must readily escape from the cut ends of the vessels, when full, of such timbers as Eucalptus, for in these the vessels are very large.

As will be seen from Fig 4, as soon as drying commences a gradient is established. It does not matter at what temperature or at what humidity the wood be dried, a gradient is established. Gradients



GRAPHS ILLUSTRATING THE PROGRESSIVE DRYING OF 3 IN. TIMBER AT 40°C AND 50% HUMIDITY.

have been found in all timbers examined. A series of birch blocks were dried at room temperature, and room humidity, and after 55 days they gave the following gradient from the evaporating surface to the centre of the block:—

Percentage of moisture in each ½ inch.

16	**23**	**29**	**34**	**37**	**39**

Drying was very slow, nevertheless a graidient was formed.

If a graident be formed, then there can be no such condition as fibre saturation. It is believed that no shrinkage takes place until this so-called fibre saturation point is reached. As a matter of fact, in all

timbers examined shrinkage follows the gradient. This can be readily seen if blocks of timber be coated on four sides so that the moisture can only escape in one direction, preferably the radial. Shrinkage can be measured under such conditions. A block of beech 2″ x 2″ x 3″, drying at 40°C., gave the following amounts of shrinkage at the times and positions given. The 2 x 2 face was tangential, and the shrinkage occurred in the tangential direction.

TABLE II.

	Shrinkage at each distance from end.				
Days	¼ in.	½ in.	¾ in.	1 in.	1½ in.
2	.02 cms.	.02 cms.	.01 cms.	—	—
5	.05	.03	.01	—	—
7	.08	.06	.02	.01	—
11	.11	.08	.05	.04	.03
19	13	.11	.10	.10	.10

Amount of shrinkage in a beech block when drying.

In Fig. 4 are given the results of drying a series of similar oak blocks under the same conditions—40°C. and 50 per cent. humidity. The blocks were approximately 2″ x 2″ x 3″, and the longest side was in the radial direction. The four long faces were sealed, and the two 2″ x 2″ faces were exposed. Blocks were cut up at the times shown on the graphs. The distribution of the moisture was obtained as before. It will be seen that the gradient was steep at the commencement. It may be argued that such a condition indicates case hardening, but as a matter of fact no such condition existed. It will be shown later that the conditions of drying were very favourable, and that these same conditions permit of a greater amount of shrinkage than lower temperatures and higher humidities. The graphs indicate that drying is accompanied by a moisture gradient, and that no such condition as fibre saturation is reached.

Instead of a piece of timber losing its contained water until fibre saturation is reached, we may say that as soon as a surface of green timber is exposed to the air, it immediately tries to come into equilibrium with the air moisture. The vapour tension of the moisture in the wood is greater than the vapour pressure of the air, and moisture is lost. This loss is made good from the contained water of the cells immediately next to the surface. This water passes out through the outer cell wall. As soon as this water is lost a gradient begins to be established. The walls begin then to lose moisture, and as wood is hygroscopic the cell walls draw moisture from the next layer of cells. The contained water in the cells passes to the outside by means of the cell walls, not through the cavities of the empty cells. This process goes on from cell to cell. The steepness of the gradient depends partly on the rate at which the moisture is being lost, and partly on the rate at which moisture can move through the wood to the evaporating face.

If the contained water passed from cell to cell as is necessitated by the fibre saturation theory, then there would have to be osmotic substances present in the cavities of the cells, and these do not exist. There is only one path for the moisture to reach the exterior, and that path is along the cell walls. This loss continues until the vapour pressure on the outside of the face is equal to the vapour tension of the face.

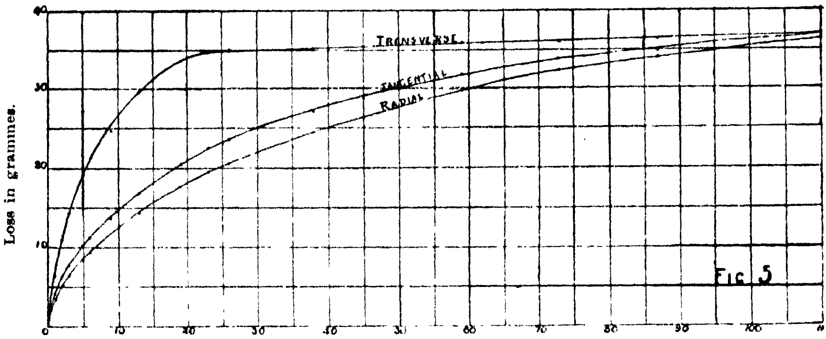
In other words, when the moisture in the wood and the moisture of the air are in equilibrium, the wood is seasoned. When exposed to the air, the weight of a piece of seasoned timber is not a constant, however, as it varies with the humidity of the atmosphere.

Evaporating Surface.—The third factor influencing the drying of timber is the face or surface exposed. There are three faces in timber—the transverse, the tangential, and the radial; and it is well known that these have different rates of drying. Wagner(3) says: "A very moist piece of pine or oak will, during one hour, lose more than four times as much water per square inch from the cross section, but only one half as much from the tangential as from the radial section." Tiemann(2) says: "The transfusion endwise of the grain is very much greater, probably ten or twenty times as rapid as it is across the grain." Again, Tiemann says: "Quarter sawed lumber will generally require 25 to 50 per cent longer to dry than plain sawed." These two authors differ widely in their opinions.

In order to ascertain what were the actual rates of loss from each face, cubes were used, and for these freshly felled timber was obtained. The timber was cut square, usually 2″ x 2″, two faces being parallel to the annual rings, and two parallel to the medullary rays. This can be done if timber from large trees be used. The length was cut transversely into cubes. Thus each cube had the same annual rings. Each cube had four faces sealed, and two corresponding faces exposed. For sealing, paraffin is undoubtedly the best material to use. The paraffin was heated to a temperature just above the boiling point of water, and the face of the cube brought into contact with it for a moment. The surface layer of moisture was evaporated, and the paraffin then came into intimate contact with the wood. All four faces of the cube were sealed in this way. After the paraffin set, the cubes were given a second coating. By this means a perfect seal was secured. For higher temperatures, the seal recommended by Tiemann(2) was used. This mixture is unsatisfactory for the first few days, when high humidities are used, as it sticks to the supports. It has this advantage, however, in that it readily indicates the shrinkage of wood, for as the wood shrinks the seal forms very fine wrinkles. When the cubes were coated they were placed in a saturated atmosphere for 24 hours at the temperature at which they were to dry subsequently. When the cubes were dried it was found in all cases that the transverse face lost the most moisture in a given unit of time. A large number of timbers, both European and Australian, have been tried, and they all give the same type of drying curves as shown in Fig. 5. A study of these curves of loss shows that the curve of loss for the transverse face always rises very sharply, and turns over

rather abruptly into a straight line. The curve for the radial face is always the lowest, but the tangential curve of loss is always close to it. The tangential curve is above the radial, not below, as indicated by the statement of Wagner. The general equation to the curves is

OAK.



CURVES OF LOSS OF MOISTURE FROM THE TRANSVERSE TANGENTIAL AND RADIAL FACES OF CUBES OF WOOD

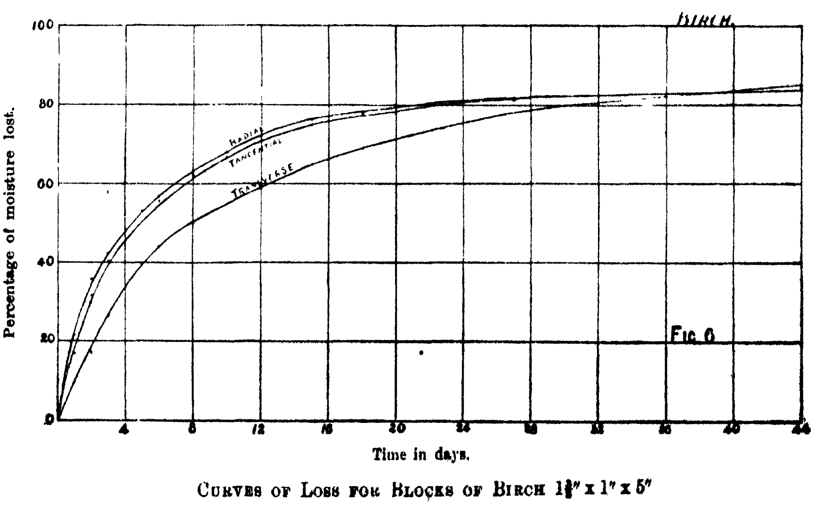
$l = at^b$ where l is the loss in weight in grams in time, "t," "a" is the loss for the first day, "t" the time in days, and "b" the index varies in value from unity to ·5, but is constant for any one curve, provided the conditions of drying are kept constant. The transverse curve has the greatest "a" value, and the greatest value for "b." When "b" is unity, the curve is a straight line, and when ·5 it is a parabola. The radial curve approaches a parabola, while the transverse curve approaches a straight line. The curves of loss for both softwood and hardwood cubes are similar. The transverse face of pine, as stated by Wagner, loses moisture, relatively just as readily, when compared with the radial, as does that of a hardwood. Hence, we are compelled to assume that the cause of this differential loss from the three faces is due to the structure of the wood itself. Water is lost most readily in the direction in which water moves in the living tree. Again the tangential face loses more moisture in a given time than the radial face. Abutting on the tangential face are the transverse sections of the medullary rays. Hence a tangential face is a complex of longitudinal sections of fibres and of transverse sections of medullary rays. If an isolated fibre of wood be examined in polarised light it will be found to give straight extinction. Transverse sections of fibres, however, do not give straight extinction. If an isolated medullary ray cell be examined in polarised light, it will be found that its length in the radial direction gives straight extinction. This leads us to conclude that the micellae of the fibres and of the medullary ray cells are arranged parallel to the length of the cell.

Now moisture finds its readiest movement, when the tree is living, along the cell walls in the direction in which the micellae are arranged. Were it not for the medullary rays, the tangential face

would lose moisture at the same rate as, or even less than, the radial. The micellae of the walls of the medullary rays are arranged in a radial direction, and it is in this direction that the water moves in them when the tree is alive. The movement of water in the plant is in some way closely associated with the structure of the cell wall, and we find in the drying of timber that the greatest losses in unit time are in the direction of greatest water movement in the living plant. Since the organisation of the cell walls of the woods of all timbers is the same, it is not surprising that the ratios of losses from the three faces are approximately the same for all timbers. While these ratios of loss may be the same, the rates of loss are not the same. All three faces have different rates of drying, and the equations to the curves are different.

As will be shown later, the curve of loss for any one face is a composite curve, and is made up of two types of curves. It is only the first type of curve that we are here considering. This curve varies, according to the drying conditions, from a straight line to a parabola. The slower the drying the nearer the curve approaches a straight line, and the faster the drying, up to a certain point, the nearer the curve approaches a parabola.

Not only does each face lose moisture at a different rate, but each rate of loss decreases differently. The face with the greatest initial loss, the transverse, has also the slowest rate of decrease. Hence we cannot cut a piece of timber so that all three faces will have the same rate of loss. Of course they could be cut so that all faces would have the same initial loss, but the losses on the subsequent days would be different. However, it is possible so to cut a piece of timber that all the curves of loss shall meet, or just cross each other, towards the end of the drying period. The curves of loss for White Birch were studied, and it was considered that if a piece of this wood was cut so that the dimensions in the tangential radial and vertical directions were as 5 : 6 : 30, the curves of loss would meet towards the end



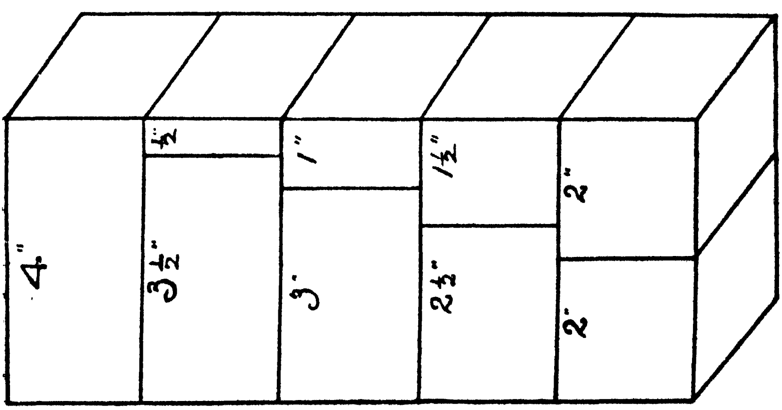
CURVES OF LOSS FOR BLOCKS OF BIRCH 1⅜" x 1" x 5"

of the drying period. A length of straight grained, freshly-felled birch was cut 1⅜″ thick radially and 1″ tangentially. This was then cut into three 5 inch pieces. One length had the two transverse faces exposed, and the sides sealed, in the second the tangential faces were exposed, and in the third the radial faces were exposed. The blocks were dried at 25°C. Fig. 6 gives the result of the experiment. The percentage of moisture lost is calculated to the total amount of moisture present at the commencement of drying. The moisture percentages of the three blocks at the conclusion of the experiment were as follow:—Radial, 10.7 per cent.; Tangential, 11.4 per cent.; Transverse, 11.1 per cent. These percentages are calculated to the dry weight of the wood.

From a study of the curves of loss for oak, it was calculated that if it were cut so that the dimensions in the tangential radial and vertical directions were as 4: 5: 20, the curves of loss would meet towards the end of the drying period. Two sets of blocks were cut, one to a size 1″ x 1¼″ x 4″, and the other 1″ x 1¼″ x 6″. The calculated length lay between the limits, 4″ and 6″. The blocks were dried at 25°C. The radial curve of loss was above the tangential until the 50th day, when they met. The differences thereafter were very small. The curve for the transverse face, in the case of the 4″ set, crossed the other curves on the 92nd day. In the 6″ set the curve for the transverse loss was still below the other curves on the 104th day, when the experiment finished. In the 4″ set, at the close of the experiment, the percentages of moisture, calculated to the dry weight of wood, of the radial, tangential and transverse specimens, were respectively 11·8 per cent., 11·5 per cent., and 11·4 per cent. In the case of oak it appears that the ratio of the radial dimension to that of length should have been only about 1:4. In the case of birch the ratio could have been increased a little. The true ratio for inch material probably is about 1·5. This ratio of dimensions for inch material would not hold for larger material, since the decrease in the rate of loss is faster for the radial than for the tangential, and faster for the tangential than for the transverse. This is because in the expression for the curve of loss for the radial surface, the value of the index of "*t*" is lower than in the curve for the transverse. As thicknesses increase the ratios would also increase, but by what amount remains to be determined. We cannot say that the transverse face dries at a definite rate as compared with the radial, for the rate of loss is constantly changing. If a rate of loss be specified, it must be in relation either to time or moisture content. While we cannot say how much faster one surface dries than another, we may say that as far as inch material goes, quarter sawn boards, one inch in thickness, will take as long to season as tangentially cut boards about 1¼″ in thickness. Normally, most timber seasons by lateral drying, but at times end drying is important, as for instance, when large dimension material is to be used in short lengths. As an example, a kiln was being charged with long lengths of 9″ x 9″ lumber. This was to be used subsequently in 3½ ft. lengths. In this case if the timber had been cut into short lengths first, time would have been saved, as the manufacturing length was less than five times the width.

End drying is important in this state owing to the loss which is caused, both in stacks of sawn timber, and in logs, through the large cracks occurring in the ends. Much of our tall, straight-grained timber is very fissile, and, therefore, splits much more easily than most timbers. The cause of the cracks at the ends of both logs and stacked timber is mainly the prevention of lateral drying. In the log, lateral drying is prevented either by the bark or by the thickness of the log, or by both. In stacked timber lateral drying is prevented, if no ventilation is provided for. Only the outside pieces can dry laterally, and then only from one side. As we have already seen, shrinkage commences as soon as a gradient is formed. Shrinkage, however, is prevented from taking place where only end drying is occuring, owing to the rigidity of the adjacent portions of the timber. Ehd drying affects only a few inches, and the timber in this short length is held in position by the remainder of the length. As the wood is drying, it tends to occupy a smaller volume, but if it cannot do so as a whole it must do in parts, and it therefore splits. That some of our timber will split even when correctly stacked is true, and this can only be overcome by sealing the ends with paint, or with Tiemann's mixture. In usual commercial sizes this does not affect time taken in drying, as the length is generally very many times greater than the thickness. In commercial sizes lateral drying is almost always the means by which timber is dried.

Thickness.—The fourth factor concerned in seasoning is that of thickness. For the study of the effect of thickness on time taken in drying, lengths of straight grained, freshly felled timber were used. Thicknesses up to five inches have been used. The timber was cut as in the diagram:—



The sides were coated as in the previous experiments. Where possible, three of each thickness were used, and the average loss of the three taken as the loss for that thickness. Each thickness had the same evaporating surface, and the various blocks differed only in thickness.

In Table III. are given the results of the first experiment. The timber was messmate (*Eucalyptus obliqua*), and the evaporating faces were four inches square. The thicknesses ranged from half an inch by half inches to three and a-half inches. The blocks were left to dry on the laboratory table. The experiment commenced in the middle of summer, and the effect of winter is seen by the decrease in

TABLE III.

Time in Days	Total losses of each thickness						
	3½ in	3 in	2½ in.	2 in.	1½ in.	1 in.	½ in.
	gms.	gms.	gms	gms.	gms.	gms	gms.
1	9	12	11	11	11	10	11
2	15	19	17	17	18	16	17
3	22	25	23	24	23	21	20
5	29	33	31	31	30	28	24
7	35	39	38	37	36	34	26
11	45	47	47	47	45	42	26
18	61	62	61	63	60	53	28
25	72	73	72	74	69	59	27
32	81	82	81	83	77	62	27
39	87	89	87	89	81	61	26
46	93	94	92	94	84	61	26
53	99	100	98	99	89	—	—
69	112	113	112	111	96	—	—
87	123	124	122	120	98	—	—
115	142	142	139	134	102	—	—
141	148	149	145	137	101	—	—
195	168	168	161	145	102	—	—

Each thickness loses approximately the same amount of moisture in a given time.

loss of some of the blocks and a subsequent increase in weight. This occurred in the inch and half inch specimens..

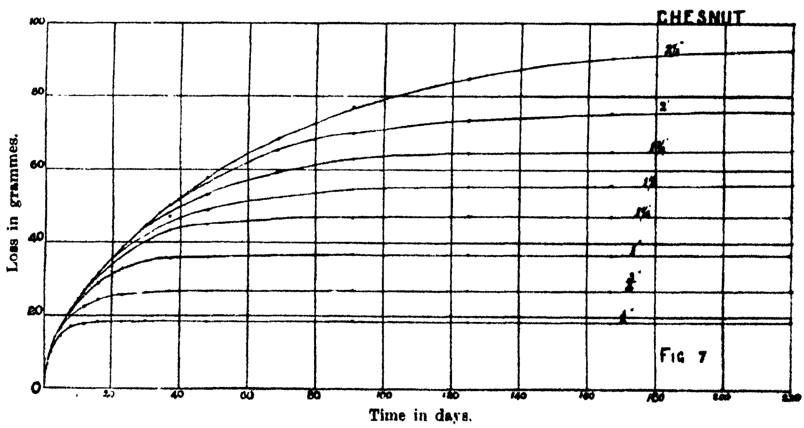
The total losses on the left of the heavy line for any particular day are approximately equal. The table shows that up to a certain point, the amount lost in a given time is quite independent of the thickness. Each thickness loses the same amount until the reservoir of moisture begins to be exhausted, and after that there is a different type of curve for the loss of moisture. Experiments with Oak, Elm, and Chestnut all gave similar results. In Fig. 7 is given a typical family of curves of loss for a series of blocks, having 2″ x 2″ faces, and ranging from half an inch by half inches to two and a-half inches. The outer curve or envelope is the curve of loss for the thickest specimen. The equation to this curve is approximately, $l = 6 \cdot 75 t'^{554}$, where l is the total loss of weight in grams in time "t," 6·75 is loss in weight in grams for the first day, and "t" is time in days. The irregularities of the secondary curves at the point of junction with the main curve have been smoothed out. In this series only one specimen was used for each thickness. The differences between the

values of the calculated losses and those actually obtained by weighing are given in the following table:—

TABLE IV.

Time in Days.	Calculated Loss $l=6.75t^{.554}$	Actual Loss.	Difference.
5	16.46 gms.	16.35 gms.	+.11 gms.
8	21.35	21.45	—.10
16	31.35	31.40	—.05
23	38.34	38.65	—.31
37	49.87	50.10	—.23
48	57.62	57.80	—.18
69	70.52	69.20	+1.32

From an examination of Fig. 7 it will be seen that drying commences and continues for a while as if the supply of moisture was inexhaustible. However, in a given thickness the amount of moisture is limited, and therefore the curve of loss leaves the initial curve, and finally becomes a straight line. Where the one curve leaves the other it is difficult to say In the small thicknesses the change is somewhat abrupt, but as thicknesses increase the change becomes less and less abrupt. This is because the secondary curve does not leave the main curve at the same moisture content in each case. In the small



SERIES OF CURVES ILLUSTRATING LOSS OF MOISTURE FOR VARIOUS THICKNESSES OF TIMBER.

sizes the moisture has only a small distance to diffuse, in order to reach the surface, and hence the curve of loss for thin sections coincides with the envelope for a relatively longer period than do the curves of loss for thicker sizes. The rate of loss is greater on the main curve than on the secondary, and hence these sizes dry rapidly. This was observed by Tiemann (2), for he says: "For one half inch or

less the time should be decreased as the square of the fractional part of an inch." Again, he says, for thickness above an inch, "The time ordinate should be increased in proportion to the thickness up to three inches, and about one and a-half times the thickness for thicknesses over three inches."

Humidity and Temperature.—The fifth factor with which drying is concerned is that of humidity, and with this we may conveniently consider the sixth factor, temperature. Humidity is not a satisfactory variable to use, since it is only a relative quantity. When we speak of a humidity we must always specify a temperature. The same humidity at different temperatures gives very different drying conditions. Drying depends on the difference between the vapor pressure of the air surrounding the wood and the vapor pressure at saturation. At a temperature of 50°C. and a relative humidity of 90 per cent., there is a difference in pressure between that actually existing and that at saturation point of 9.25 mm. of mercury. At a temperature of 20°C. and the same humidity, namely, 90 per cent., there is only a difference of 1·75 mm. Hence there is a very great difference in the rate of drying of timber, when placed under these two sets of conditions. A high humidity at a high temperature may cause timber to dry at a much faster rate than a low humidity at a low temperature. Thus blocks drying at 80 per cent. humidity at 50°C. were losing moisture faster than those at 10 per cent. humidity at 20°C. This point is frequently lost sight of in kiln drying, when it is recommended to commence the seasoning at a high temperature and a high humidity.

Experiments were carried out at different humidities, at the temperatures 20°, 30°, 40° and 50°C. For the experimental work blocks approximately 2″ x 2″ x 1″ were used. For any one experiment the blocks were cut from the same length of timber. Only straight grained, freshly felled material was used. The sides of the specimens were sealed, leaving the 2″ x 2″ faces exposed. The exposed faces were always radial surfaces. To obtain the various humidities, solutions of sulphuric acid were used. After each weighing, the solution in each desiccator was brought up to strength by adding the amount of acid corresponding to the loss of weight of the specimen. For desiccators, tall gas cylinders were used, and the specimens were supported on glass rods. The humidities used ranged from 95 per cent. down to 2 per cent. There were two humidities below 10 per cent., namely 7 per cent. and 2 per cent.

In the experiment at 20°C. losses increased with decreasing humidity. The greatest loss occurred at the lowest humidity, that is at 2 per cent. At the other temperatures, however, the maximum loss occurred at 7 per cent., and the curve of loss bent downwards from the 7 per cent. to the 2 per cent. humidity. This is shown in Fig. 8, which gives a typical series of losses. Similar graphs were obtained with beech, elm, and chestnut. A duplicate experiment with oak at 50°C. gave precisely the same type of graph. Owing to limitations of space and material, only single specimens could be used at each humidity, but the greatest care was taken in the selection and cutting

of the material. In the case of Fig. 8 the heaviest specimen was 64:5 gms., and the lightest 64:12 gms., so that the differences in the weight of the specimens were negligible.

OAK 30°C

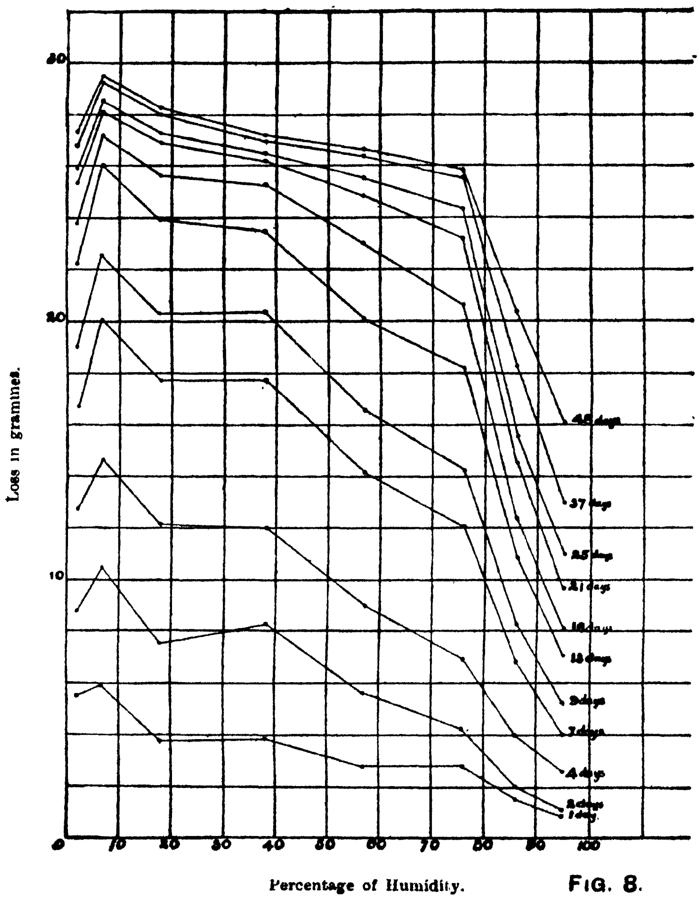


FIG. 8.

TYPICAL SERIES OF LOSSES IN WEIGHT OF BLOCKS, DRYING AT VARIOUS HUMIDITIES.

Since in all the experiments, except that at 20°C, the graphs bent downwards between the 7 per cent. and the 2 per cent. humidities, there does appear to be a limiting humidity below which drying is retarded. Low humidities rarely occur in nature, though it is believed as low a humidity as 4 per cent. has been experienced in this State. As far as air drying in this State is concerned, therefore, we may say that drying would never be retarded. It has already been remarked that the curve of loss is a composite curve, and is made up of two types of curves. The first part of the curve of loss gives the losses when the wood is actively drying. These losses will now be

considered. In Table V. are given the ratios of the loss of weight on the first day to those on subsequent days. In this experiment the blocks were dried at 90 per cent. humidity.

TABLE V.

Temp.	Time in Days. 4	9	15	25
20	4	9	16	22
30	3.1	6.6	9.0	11.8
40	2.9	3.7	5.6	—
50	{3.6	7.0	8.7	—
	3.2	6 6	7.8	—

Ratios of loss at 90% Humidity.

It will be seen that in the case of the specimen at 20°C. the ratios are the same, except the last, as the time in days. In other words, the curve of loss is a straight line. As will be seen in Fig. 9, when this happens drying is very slow. It will also be seen that the higher the temperature the less the ratio, although it may be noted that an exception occurrs at 40°C. This happened with every specimen at 40°. There was no material available for a second experiment. The second experiment at 50°C. gave similar results to the first.

In Table VI. are given the ratios of loss for specimens drying in a 50 per cent. humidity.

TABLE VI.

Temp.	Time in Days. 4	9	16	25
20	3.6	7.4	12.5	17.1
30	2.9	5.1	6.4	7.1
40	2.0	3.0	—	—
50	{2.8	4.1	5 1	—
	2.5	3.6	4.5	—

Ratios of loss at 50% Humidity

The ratios in the case of 20°C. are somewhat removed from the values of the time in days. There is again a decrease in the ratios with increasing temperature. In Table VII. are given the ratios of loss for specimens drying at 10 per cent. humidity.

TABLE VII.

Temp.	Time in Days 4	9	16	25
20	3.5	7.1	10.1	12.5
30	[illegible].5	3.9	4.7	5.0
40	2.0	—	—	—
50	{2.4	.4	—	—
	2.	3.2	—	—

Ratios of loss at 10% Humidity.

The ratios are only calculated for the period of active drying. In the last table it will be seen that the values of the ratios approach the value of the root of the time. In the 40° experiment the ratio is actually *t*. From all the tables it will be seen that the ratio of the first day's loss to any subsequent loss always lies between "*t*" and "$\sqrt{t}$." It never goes outside these limits. With high humidities the curve of loss always approaches a straight line. The nearer, however, that the curve of loss approaches a straight line the slower

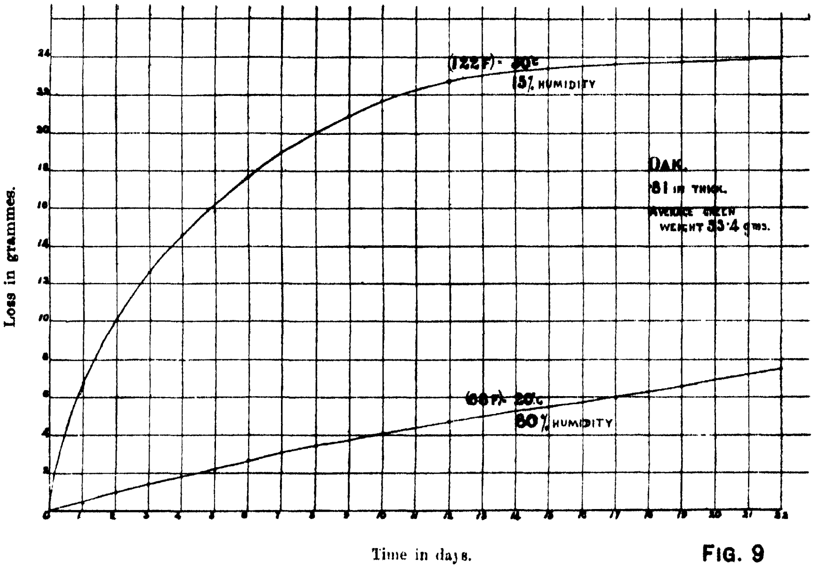


FIG. 9

TWO TYPES OF DRYING CURVES, THE UPPER HIGH TEMPERATURE AND LOW HUMIDITY, THE LOWER LOW TEMPERATURE AND HIGH HUMIDITY.

the drying, as is well shown in Fig. 9. In this last figure are shown two curves of loss, one for drying at 50°C. and 15 per cent. humidity, the other at 20°C. and 80 per cent. humidity. In both cases the vapor pressure was 14 mm. Each curve is the average of three results. The slower the drying the nearer the curve approaches the time axis. The general formula for this period of drying is $l = at^b$ where *b* varies from unity to ·5. As *b* increases in value from ·5 to 1, the value of "*a*" decreases. The smaller the value of "*b*" within the limits stated the faster the rate of drying. Rapid drying, however, although advantageous from the point of view of saving of time increases the amount of shrinkage. This is not surprising, for it is quite conceivable that the higher temperatures make the wood somewhat plastic. Increase of shrinkage is very undesirable from a commercial point of view. What has recently been termed collapse in timber is in many cases undoubtedly due to high temperatures in the kiln. In Table VIII. are given the amounts of shrinkage for a series of oak blocks, averaging 2·06 cms. in thickness. Three blocks were

dried at each temperature, and at the humidities given in the table. After the completion of the experiment the blocks were left on the shelf in the laboratory for twelve months, before the final measurements were made for the amount of shrinkage. The moisture contents of the blocks at the final measuring were very similar.

TABLE VIII.

Temperature.	Humidity.	Shrinkage.
20°c.	80%	.13 cms.
30°	44	.15
40°	25	.17
50°	15	.20

Amount of shrinkage increases with better drying conditions.

That the greatest amount of shrinkage occurred at the highest temperature is evidence that there was no case hardening, so-called. It has been shown (4) that a rapid loss of moisture from the surface prevents shrinkage to a certain extent. It has also been shown (4) that steaming timber prior to seasoning induces shrinkage. Both high temperatures and steaming are recommended in ordinary commercial operations in kiln drying. In Fig. 9 are given the drying curves of two series of blocks, one drying at 20°C. and other at 50°C. The drying conditions of the series at 50°C. are representative of the best drying conditions found in nature in this State during the summer. The highest temperature recorded in this State is 123·5°F. The equivalent temperature of this in degrees centrigrade is 51°.

Humidities lower than 15 per cent. are frequently recorded. The blocks were radially cut, and were ·81 inches thick. This thickness would take about the same time to dry as tangentially cut specimens one inch thick. The lower curve is representative of drying under more or less average weather conditions. The upper tends to prove what has already been pointed out (4) that inch boards can season in this State in a few weeks.

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3. **Seasoning of Wood. J. B. Wagner.**
4. **On the Seasoning of Hardwoods. Proc. Roy. Soc. Vict., 1919, by R. T. Patton.**

[PROC. ROY. SOC. VICTORIA 35 (N.S.), PT. I., 1922.]

ART. VI.—*Contributions from the National Herbarium of Victoria, No. 2.*[1]

By J. R. TOVEY and P. F. MORRIS.

(With Plate VI.)

[Read 8th June, 1922.]

ARISTIDA BEHRIANA, F.v.M. "Brush Spear Grass." (Gramineae).

North Wangaratta, Mrs. A. M. C. Nason, November, 1920, and September to November, 1921.

An additional locality in Victoria for this native grass. It was previously recorded from the north-western district of Victoria. It is found also in New South Wales, Queensland and South Australia.

HELIPTERUM AUSTRALA (A. Gray), Ostenf in Danske Videns Selsk. Biol. Medd. III., 2, 142 (1921), (*Dimorpholepis australis*, A. Gray (1852). (*Helipterum dimorpholepis*, Benth (1866), (Compositae).

Under the laws of botanical nomenclature Gray's original specific name has priority over that of Bentham's. Druce, in Heyward and Druce Advent, Fl. Tweedside P., 103 (1919), proposes *Helipterum pygmaeum*, Druce, (*Triptilodiscus pygmaeus*, Turcz (1851), for this species, but we have already a *H. pygmaeum*, Benth. (*Pteropogon pygmaeus*, D.C. (1837). A. Gray's name must be used, and not Turczaninow's.

HELIPTERUM ROSEUM, Benth. var. patens (Ewart), Black (Compositae).

In the Trans. Roy. Soc., S.A., XLV., 21 (1921), under the above heading, J. M. Black has placed *H. Troedelii*, F.v.M. var. *patens*, Ewart, as a synonym. The reasons given evidently justify this course.

The following localities were quoted, i.e., Ooldea, Miss D. Bates, July, 1920, Mt. Lyndhurst, M. Kock, No. 1644 (1889) and Fraser Range, W.A., R. Helms (1891). The latter two were also given in the Proc. Roy. Soc. Vict., XXII., 15 (1909), where the varietal name was first published. The specimens from Mt. Lyndhurst were inserted in the variety *patens* in error. As their stems and branches are beset with appressed, lanuginous vestiture, as in *H. Troedelii*, whilst those of the variety *patens* are glabrous, the inflorescence of the Mt. Lyndhurst specimens are similar to those of *H. Troedelii*, and hence must be transferred from the variety, *H. roseum*, var. *patens*, to *H. Troedelii*. Mr. Black had not seen Kock's specimens from Mt. Lyndhurst, but only quoted from the Proc. Roy. Soc. Vict. Specimens have since been submitted to him, and he has confirmed our determination.

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1 No 1. in Proc. Roy. Soc. Vict. vol. XXXIV., p. 207, 1922.

MICROSERIS SCAPIGERA, Sch. Bip. in Pollichia XXII.-XXIV., 310 (1866), (O. Hoffm. in Englers Pflanzenfamilien Teil IV. Abt. 5, p. 358 (1894), (*Scorzonera scapigera*, Forst. Prod. 534 (1786), (*Microseris Forsteri*, Hook, f Fl. Nov. Zel. 1, 151 (1853), (Compositae.)

According to Article 48 of the Vienna Botanical Congress (1905), Forster's original specific name has priority over that of Hooker's.

OXALIS PURPURATA, Jacq. "Purplish Wood-Sorrel" (Oxalidaceae).

Kyneton, Victoria, E. J. Semmens.

An additional locality in Victoria for this South African weed.

PAULOWNIA TOMENTOSA, Steud. (*Paulownia imperialis*, Siebold, and Zuc.), "Downy or Imperial Paulownia" (Scrophulariaceae).

A hardy, deciduous tree, height 20 to 30 ft. Branches horizontal tortuous; leaves opposite, entire or three-lobed, broad, soft, villous or pubescent, 6 to 18 inches long; flowers showy; corolla pale violet, with dark spots on the inside, 1½ to 2 inches long, with an elongated tube, and a five-lobed spreading limb; panicles terminal, with opposite, many-flowered branches. Capsule usually 1 in. long, ovoid acuminate, In a rocky gully on the edge of a stream at Wandiligong, Victoria, J. A. Fraser, March, 1922.

This deciduous tree is a native of Japan, and has not been previously recorded as growing wild in Victoria. It is sometimes grown in gardens as an ornamental tree. The seed has probably been carried down the stream by storm water and lodged in the gully, where it has propagated and developed into a tree. As it is only recorded from one locality, it may be classed as an exotic not yet sufficiently established to be considered naturalised.

PTEROSTYLIS ALATA (Lab.), Reichb, f, var. ROBUSTA (Ewart), comb. nov. (*P. praecox*, Lindl. var. *robusta*, Ewart, in Proc. Roy. Soc. Vict. XXVII., 234 (1916).

Herba 10-15 cm. alta; foliis et floribus majoribus quam typi— *P. alata.*

The general appearance and habit of the plant is the same as *P. alata*, but it is taller and stouter, the hood being 2-3 times as large.

SCORZONERA LACINIATA, L., "Torn Vipers Grass" (Compositae).

A perennial with long tapering roots; stems sub-erect, naked and one-headed at the apex; leaves deeply cut (pinnatisect); lobes linear, entire; flowers yellow, involucral scales slightly hooked at the apex.

Kerang district, E. J. Semmens, Sept., 1921.

It is a native of the Mediterranean regions and the Caucasus. It has not been previously recorded as growing wild in Victoria. It may be classed as an exotic not yet sufficiently established to be considered naturalised. Several species of *Scorzonera* are cultivated in gardens for the use of their long, tapering roots, which are cooked in a similar way to those of the "Salsify."

SOLANUM ROSTRATUM, Dunal. "Buffalo Burr," or Pincushion Nightshade" (Solanaceae).

Annual, herbaceous, woody when old; somewhat hoary or yellowish; 8 inches to 2 feet high; covered with copious stellate pubescence; the branches and stems covered with sharp, yellow prickles; leaves 1-3 times pinnatifid; lobes roundish or obtuse, with uneven margins, covered with soft pubescence, hairs star-shaped; flowers yellow; corolla gamopetalous, 1 in. in diameter, nearly regular, the sharp lobes of the corolla broadly ovate; stamens, 5 declined, anthers tapering upward, linear lanceolate, dissimilar, the lowest much larger and longer with incurved beak, hence the technical name rostratum; style much declined; fruit a berry, but enclosed by the close fitting and prickly calyx, fruit erect; seeds thick, irregular, round or somewhat longer than broad, wrinkled showing numerous small pits; seeds surrounded by a gelatinous substance.

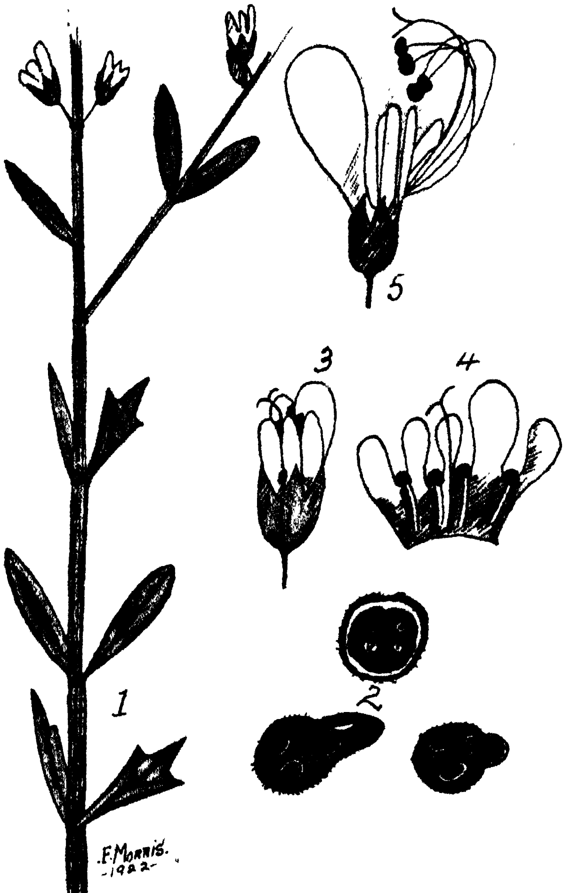
Echuca, W. W. Cain, March, 1909; Benalla, W. B. Tiernan, Jan., 1913; Boweya, Vic., Feb., 1915; Neilborough district, Feb., 1921; also in New South Wales and South Australia.

In the "Weeds, Poison Plants and Naturalised Aliens of Victoria, the foregoing specimens are given under the name of *Solanum heterandrum*, Pursh., but on critical examination the material (in the Herbarium) from Australian localities proved to be identical with authentic specimens of *S. rostratum*, Dunal., and agreed with the description of that species. The North American material (in our Herbarium), apparently authentically labelled *S. heterandrum*, Pursh., also agreed with the specimens and description of *S. rostratum*, Dunal.; *S. heterandrum*, Pursh. is therefore apparently a synonym to *S. rostratum*, Dunal., and will have to be deleted from the list of the Introduced Flora of Victoria, and *S. rostratum* substituted for it.

SOLANUM TRIFLORUM, Nutt., "Spreading or Three-flowered Nightshade" (Solanaceae).

Annual, low spreading, slightly hairy or nearly glabrous, leaves acute, pinnatifid 7-9 lobed; peduncles, 5-3 flowered; corolla white; berries greenish or inclined to blackish, about the size of a small cherry; pedicles reflexed in fruit.

Black Mountains, 83 miles east of Bairnsdale, Vic., J. Clyde Rogers, Feb., 1922 (per G. Renner, Botanical Assistant, Department of Agriculture). Professor Chesnut says experiments on guinea pigs show that the berries are poisonous. The active constituent is no doubt solanin. The berry is not attractive to the eye, but has an agreeable odour and taste. This plant, a native of North-West America, has not been previously recorded as growing wild in Victoria, but it will probably be found to have a fairly wide range, and is likely to become a troublesome pest if allowed to spread. This plant has been brought under the provisions of the Thistle Act for the whole State.



Teucrium racemosum, R.Br.
var. polymorphom, var. nov.

TEUCRIUM RACEMOSUM, R. Br. var. POLYMORPHUM, var. nov. (Labiatae), **Corona 1-1½''' longis, staminis non exertis, stigmatis brevissimis exertis.**

Kerang, Victoria, E. J. Semmens, September, 1920.

The variety somewhat resembles the type *T. racemosum*, from which it differs in having the stamens inserted in the corolla and not exserted, the stigma only slightly exserted. The ovary has four cells in most cases, two of the cocci are non-fertile or abortive.

TRICHINIUM EXALTATUM, Benth. "Lambstails," (*Amarantaceae*).
Dookie district, Victoria, D. McLean, November, 1921.

A new locality in Victoria for this native plant; it was previously recorded in Victoria from the north-western district only; it is also found in all the other Australian States except Tasmania.

DESCRIPTION OF PLATE VI.

TEUCRIUM RACEMOSUM, R. Br. var. POLYMORPHUM, var. nov.

Fig. 1.—Portion of plant.
,, 2.—T.S. of ovary, showing variation of cells.
,, 3.—Flower (magnified).
,, 4.—Corolla (magnified), showing length of stamens and stigma.
,, 5.—Flower of *T. racemosum* (magnified).

[PROC. ROY. SOC. VICTORIA 35 (N.S.), PT. I., 1922.]

ART. VII.—*Gravity Determinations in Australia.*

By E. F. J. LOVE, M.A., D.Sc., F.R.A.S., F. Phys. Soc. Lond.

[Read 13th July, 1922.]

§ 1. Introduction.

The recent appointment, by the National Research Council of Australia, of a committee to report on the subject of a gravity survey of the continent, necessitates a critical discussion of the determinations of the gravitational acceleration which are already in existence. As regards those for Brisbane, Hobart and Perth, little can be said; each depends on a single set of observations, and, until checked, must be regarded as provisional. The work of Budik at Brisbane and Hobart is considered by Helmert[1] to be affected by a mean error of $\pm 0 \cdot 010$ cm. sec^{-2}; to that of Alessio, at Perth[2], the mean error $\pm 0 \cdot 007$ may be assigned. We therefore have, as provisional values only—

For Brisbane	:	$g = 979 \cdot 148 \pm 0 \cdot 010$ cm. sec^{-2}
„ Hobart	:	$g = 980 \cdot 441 \pm 0 \cdot 010$ „ „
„ Perth	:	$g = 979 \cdot 374 \pm 0 \cdot 007$ „ „

The case is different as regards the Melbourne and Sydney observatories. For each of these we have a determination by means of Kater pendulums, and several others by means of half-seconds pendulum, both of the von Sterneck and Potsdam types. Suitable averaging of these should therefore furnish definite values of g for both stations; also of their difference, which has an importance of its own, as it has already served,[3] and may possibly serve again, as a sort of "Fundamental Interval," for the calibration of gravimeters of statical type.

An error pointed out by Helmert (*l.c.*) necessitates a partial revision of the Kater pendulum reductions; this constitutes §2. §3 contains the evaluation of g for the two observatories, and §4 deals with the gravitational anomalies. The Appendices contain details which it seemed advisable to keep apart from the main paper. The notation is that in general use among geodesists. The methods of the theory of errors are used in the computing; the small quantities preceded by the sign $\pm$ are in all cases mean error.

§ 2. Revision of Results of Observations with Kater Pendulums.

Helmert (*l.c.*) has taken exception to the formula employed, both by Baracchi and myself,[4] in the reduction of our observations to the

1. Assoc. Geodes. Int., compt. rend. 13 ieme conf. gen.; II.e vol., 1901. Frequent reference is made to this paper.

2. His work at Perth and at Melbourne is about on a par; the latter is discussed in §3.

3 Threlfall and Pollock, Phil. Trans. 193 A, 1900.

4. Proc. Roy. Soc. Vict., 1893, p. 168; do., 1894, p. 8.

standard pressure of 26·in. of mercury at 32°F. His criticism is sound as regards the form, but in error as to the numerical coefficient.

The formula employed by previous workers was—

$$0.32 \left\{ \frac{B}{1+0\cdot0023(F-32)} - 26 \right\} \text{ vibration/day,}$$

where B denotes the *uncorrected* barometer reading and F that of the Fahrenheit thermometers employed. But according to the data supplied to us by General Walker,[5] the coefficient 0·32 should be replaced by 0·34. The formula used by us was, however,

$$0\cdot34 \frac{B-26}{1+0\cdot0023(F-32)} \text{ vibration/day.}$$

where B now denotes the *corrected* barometer reading; the computed vibration numbers for the pendulums were accordingly too large. Now the expression, $1+0\cdot0023(F-32)$, is really an approximation to $[+ 0\cdot0022(F-32)]\ [1+0\cdot0001\ (F-32)]$, the first factor being the density-temperature reduction for air (containing moisture), the second the barometer reduction. To correct the eror we must therefore add to the mean observed vibration number of each pendulum at each station the appropriate numerical value of

$$0\cdot34 \left\{ (B-26)\frac{0\cdot0001(F-32)}{1+0\cdot0023(F-32)} - 26\frac{0\cdot0023(F-32)}{1+0\cdot0023(F-32)} \right\}$$

For these values I obtain

Pendulum No.	Melbourne.	Sydney.
4	−0·438	−0·703
6	−0·438	−0·704
11	−0·438	−0·708

which give for the corrected vibration numbers and their differences, in place of those in our previous papers (*q.v.*)

Pendulum.	Melbourne.	Sydney.	Difference.
4	86098·83	86086·40	12·43
6	85998·99	85986·42	12·57
11	86050·62	86037·69	12·93
		Mean difference	12·64±0·15

To obtain the difference, g (Melbourne) − g (Sydney), we have, therefore, to a sufficient approximation

[g (Melbourne) − g (Sydney)]/g (Melbourne) = 2·94 10^{-4}; also g (Melbourne) = 980·0.cm sec^{-2} – – (*q.p.*) whence g (Melbourne) − g (Sydney) = 0·288 ± 0·003.cm sec^{-2}. For reasons given in Appendix 1, this figure is increased by 0·002, giving

$$g\ (\text{Melbourne}) - g\ (\text{Sydney}) = 0\cdot290.\text{cm sec}^{-2}$$

so far as the Kater pendulums[6] are concerned. The Kater pendulum

5. General Walker's letters and "Instructions to Observers" are preserved at the Melbourne Observatory.

6. The differences obtained with half-seconds pendulums range from 0·299 to 0·313.cm sec^{-2}.

value of g for Sydney is 979·687.cm sec^{-2} on the Potsdam system; consequently the corresponding value for Melbourne is 979·977.cm sec^{-2}. This figure replaces both the previous incorrect one, viz.: 979·969, and Borrass's semi-conjectural emendation of it, 979·993, which is given in many tables.

§ 3. Gravity at the Melbourne and Sydney Observatories on the Potsdam System.

This problem has already been discussed in part by Borrass,[7] but his discussion requires revision in view of Alessio's subsequently published work,[8] and of the results in §2 above.

Alessio's outfit was, in its main features, a replica of Hecker's;[9] their observations are characterised by much the same care and attention to detail, and each determined the flexure correction at every station, instead of trusting to its constancy as all previous experimenters had done. They differ, however, in that Hecker used five pendulums as against Alessio's four. They differ also in their manner of observing, in that Hecker used his own clock, while Alessio used clocks in regular use at the observatories, in preference to his own, arguing quite justly that a clock in steady work is less liable to systematic acceleration of rate than one recently set up;[10] on the whole, Alessio's procedure seems to be slightly the more advantageous. Comparison of their work discloses no other material advantage on either side as regards method. Nevertheless, the mean errors of their results differ, Hecker's being decidedly the smaller, especially for Sydney. Alessio's Melbourne determination is therefore assigned three-fourths, his Sydney determination one-half the weight of Hecker's.

For the relative weights, as compared with Hecker's, of other determinations in which half-seconds pendulums were used, Borrass's (*l.c.*) estimates are accepted.

As regards the Kater pendulum determinations, Helmert (*l.c.*) has assigned to that obtained at Sydney the same mean error, ±0·010, as to those of von Elblein and Budik; the corresponding mean error for the Melbourne determination—in which twice as many experimental stations are involved—would be ±0·014; but, for reasons given in Appendix 1, this is increased to ± 0 020; hence the Melbourne determination is allowed half the weight of the Sydney one.

The data for the evaluation of g for the Melbourne observatory are given in Table I.

7. Assoc. geodes. int., compt. rend. 16 ieme conf. gen., III.e vol., p. 224. Frequent reference is made to this paper.

8. Osservazioni Gravimetrische, Genova, 1912. I owe my copy of this paper to Dr. Baldwin's kindness.

9. Hecker's masterly pendulum work is detailed in a series of monographs published by "Zentralbureau der Internationalen Erdmessung," and "Koniglich-preussisches geodatisches Institut."

10. Further details on this point are given in Appendix 2.

TABLE I.

Observer.		Type of apparatus.		g cm. sec.$^{-2}$		Weight.		Diff. from weighted mean
Baracchi-Love	-	Kater	-	979·977	-	0·5	-	− ·010
v. Elblein	-	v. Sterneck	-	·991	-	1·	-	+ ·004
Guberth	-	,,	-	·997	-	1·	-	+ ·010
Hecker	-	Potsdam	-	·985	-	2·	-	− ·002
Alessio	-	,,	-	·985	-	1·5	-	− ·002
			-	Weighted mean: 979·987				
			-	Mean error: ±·0027				

Bernacchi's determination is omitted; Borrass also omits it. Wright's determination is, apparently, not yet published.

The data for the evaluation of g for the Sydney observatory are given in Table II.

TABLE II.

Observer.		Type of apparatus		g cm. sec.$^{-2}$		Weight.		Diff from weighted mean.
Smith	-	Kater	-	979·687	-	1·	-	+ ·007
v. Elblein	-	v. Sterneck	-	·678	-	1	-	− ·002
Guberth	-	,,	-	·698	-	0·5	-	+ ·018
Budik	-	,,	-	·686	-	1·	-	+ ·006
,,	-	,,	-	·674	-	1·	-	+ ·006
Hecker	-	Potsdam	-	·681	-	2·	-	+ ·001
Alessio	-	,,	-	·675	-	1·	-	− ·005
			-	Weighted mean: 979·680				
			-	Mean error: ±·0018				

Duperrey's determination (included by Borrass) is omitted, as it was not made at the observatory.

From Tables I. and II. we obtain the definite values:—

For Melbourne Observatory: $g = 979{\cdot}987 \pm {\cdot}002_7$ cm. sec.$^{-2}$
For Sydney ,, $979{\cdot}680 \pm {\cdot}001_8$,,
For difference: g (Melb.) − g (Syd.) $= 0{\cdot}307 \pm {\cdot}003_2$,,

Both stations are obviously well established, the mean errors being quite small for results based on so many observations, and so large a range of methods; Sydney observatory, indeed, takes rank among the best established stations. Either would serve the purpose of a primary station for gravity survey.

§ 4 Gravitational Anomalies.

The additional figures required to obtain these anomalies are given (except those for Perth) by Borrass (*l.c.*). Taking first those

for Melbourne and Sydney we obtain, in terms of the Helmert geoid of 1901, viz.:—

$$\gamma_0 = 978{\cdot}030\ (1 + 0{\cdot}005302\sin^2\phi - 0{\cdot}000007\sin^2 2\phi),$$

for Melbourne: $g_0 = 979{\cdot}995$, $g_0'' = 979{\cdot}992$, $\gamma_0 = 979{\cdot}974$,

$g_0'' - \gamma_0 = +{\cdot}018$, $g_0 - \gamma_0 = +{\cdot}021$

for Sydney: $g_0 = 979{\cdot}693$, $g_0'' = 979{\cdot}689$, $\gamma_0 = 979{\cdot}634$,

$g_0' - \gamma_0 = +{\cdot}055$, $g_0 - \gamma_0 = +{\cdot}059$

In terms of the Helmert geoid of 1915, in which the ellipticity of the equator and parallels first makes its appearance (and that with a somewhat surprisingly large coefficient for the longitude term) I find that both anomalies are much smaller. The equation of the new geoid is:—

$$\gamma_0 = \underset{\pm 3}{978{\cdot}052}\ [1 + \underset{\pm 5}{0{\cdot}005285}\sin^2\phi - 0{\cdot}000007\sin^2 2\phi$$

$$+ \underset{\pm 3}{0{\cdot}000018}\cos^2\phi\cos 2(\lambda + \underset{\pm 4}{17})]$$

where λ denotes the longitude, reckoned positive when E. of Greenwich. Hence we obtain:—

for Melbourne: $\gamma_0 = 979{\cdot}999$, $g_0'' - \gamma_0 = -{\cdot}007$, $g_0 - \gamma_0 = -{\cdot}004$,

for Sydney: $\gamma_0 = 979{\cdot}662$, $g_0'' - \gamma_0 = +{\cdot}027$, $g_0 - \gamma_0 = +{\cdot}031$.

The negative sign of these anomalies for Melbourne is noteworthy. Melbourne is, to all intent, an inland station in an extended region of low topograhic relief;[11] for it, therefore, the free-air and isostasy anomalies are not likely to differ much, and the negative sign of the former may possibly be correlated with its position in a region largely covered with relatively light rocks of late geological age, and, where of earlier age, mainly Silurian. Sydney, being a coastal station near to deep water, the correlation between its gravitational anomaly and the geological age of the neighbouring surface rocks is very likely to be masked by a large topographic effect, of which the Bouguer and free-air reductions fail to take account; a fresh reduction by the Hayford-Bowie method might clear up this point.

The anomalies, $g_0'' - \gamma_0$ and $g_0 - \gamma_0$ for Brisbane and Hobart, in terms of Helmert's 1901 geoid, are given by Borrass (*l.c.*). Those for Perth,[12] together with the anomalies for all three stations in terms of the 1915 geoid, are as follows:—

1901 geoid. Perth: $g_0 = 979{\cdot}392$, $g_0'' = 979{\cdot}387$, $\gamma_0 = 979{\cdot}477$,

$g_0'' - \gamma_0 = -{\cdot}090$, $g_0 - \gamma_0 = -{\cdot}085$*

1915 geoid, Perth: $\gamma_0 = 979{\cdot}493$, $g_0'' - \gamma_0 = -{\cdot}106$, $g_0 - \gamma_0 = -{\cdot}101$.

Brisbane: $\gamma_0 = 979{\cdot}160$, $g_0'' - \gamma_0 = -{\cdot}004$, $g_0 - \gamma_0 = .000$.

Hobart: $\gamma_0 = 980{\cdot}446$, $g_0'' - \gamma_0 = +{\cdot}007$, $g_0 - \gamma_0 = +{\cdot}013$.

The asterisked figure is also given by Alessio.

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11. Port Phillip, geodetically speaking, is a shallow lake.
12. See Appenidix 4.

The anomalies for Hobart and Brisbane are reduced, those for Perth increased, by employing the new formula; the large negative values for Perth are very curious. For the reason given in §1, these anomalies must not be trusted too far; so far as they go, they favour Helmert's new formula.

Appendix 1.

In order to ascertain the proper weight to assign to the Kater pendulum determination of g for Melbourne we must investigate—

(a) The differential character of the pendulums;

(b) The relative precision of the sets of observations.

The difference between the vibration numbers of any pair of the pendulums, being small compared with the vibration numbers themselves, will be nearly the same in all four sets if differentiality is preserved. Arranging them in order of time we have—

Pendulums.	Sydney 1882 (S).	Kew 1889 (K).	Melbourne 1893 (B).	Sydney 1894 (L).
(4)-(6)	100·61	99·47	99·84	99·98
(11)-(6)	51·76	50·24	51·63	51·27

Mean: (4)-(6) = 99·98± ·24

Mean: (11)-(6) = 51·22± ·34

It is clear that the pendulums maintained their differentiality over the whole eleven years.

For the sets we obtain the following difference table:—

Pendulum.	K—S	K—B	K—L	B—S	B—L	S—L
4	66·02	58·12	70·55	7·90	12·43	4·53
6	67·18	58·49	71·06	8·67	12·57	3·90
11	65·64	57·10	70·03	8·54	12·93	4·39
Mean	66·28	57·90	70·55	8·37	12·64	4·27
Mean error	±·46	±·42	±·30	±·24	±·15	±·19

From these figures we conclude:—

1. That there is no material difference between the precision of sets S, B and L; the weakest set is K.

2. That the pendulum support was distinctly less rigid in 1893-4 than in 1882 or 1889; but slightly more rigid during my observations than during Baracchi's, by an amount apparently corresponding to an incease in the difference, g (Melbourne) $-g$ (Sydney), of about 0·002.cm sec^{-2} above that computed from the vibration numbers; hence this addition in §2. The uncertainty, however, is not entirely removed; so I have increased my estimate of the mean error from ±0·014 to the outside value ±0·020.

Appendix 2.

Alessio found, by experiments made to test the point, that his own coincidence clock was liable to accelerations of rate (sometimes positive, sometimes negative) for a few days after starting. Hecker's clock was of the same make; risky as it is to argue from the be-

haviour of one clock to that of another, even of the same construction, the fact is significant. Hecker also found that the mere stopping and restarting of his own clock altered its rate, on one occasion, by nearly 1½.sec/day; so it had peculiarities of its own.

APPENDIX 3.

No corrections need be applied to the Sydney figures of 1882, or to the Kew figures, for the change in pressure factor from 0.32 to 0.34; the diminished pressures, under which they were obtained, were purposely chosen so as to render the pressure reductions to 26·in., at the mean temperatures of the respective observations, nearly or quite evanescent.

APPENDIX 4.

Mr. Curlewis informs me that the Perth observatory is built on solid sand; for reasons given in his letter, the sand appears to be of great depth. I have therefore assumed $2{\cdot}2\pm0{\cdot}2$ as a sufficient approximation to the density required for computing the Bouguer reduction.

[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. I., 1922].

ART. VIII.—*A Revision of the Genus Pultenaea, Part III.*

H. B. WILLIAMSON, F.L.S.

(With Plate VII.)

[Read 13th July, 1922.]

PULTENAEA CAPITELLATA, Sieber.

An authentic Victorian record for this plant is "Bendoc, C. French, Jan., 1899."

In the reference to the specimen "Port Jackson, Sieb., n. 313," in my Revision, Part I. "313" was in error written for "413."

PULTENAEA FERRUGINEA, Rudge.

Mr. A. A. Hamilton in Trans. Linn. Soc. of N.S.W., Vol. XLV., p. 262 (1920), restored this species.

I did not see Mr. Hamilton's paper, and had no intimation of what he had done till it was too late to make any reference to it in my Revision Part II., in which I also restored this species.

PULTENAEA CANALICULATA, F. v. M.

(Trans. Vic. Inst. 1855.).

A coast shrub with silky-villous terete leaves channelled above, and long, pubescent stipules. The large flowers with long calyx lobes are sessile, and crowded in the upper axils, with no bracts except the stipules of the floral leaves. The bracteoles are long, narrow, silky, and fixed below the calyx. It differs from *P. mollis* in not having capitate flower heads, in the more hairy, and sometimes golden-silky pubescence, and in its long narrow bracteoles.

On the coast from Port Lincoln to Corner Inlet.

Specimens from Cape Otway have leaves 7 lines long, with stipules over 2 lines long, while those from Warrnambool and Port Lincoln have leaves 4-5 lines long, less silky, somewhat clavate, with stipules 1 line.

Var. *latifolia*, var. nov.

Variat foliis oblongo-lanceolatis concavis subtus puberulis supra glabrescentibus.

A less hairy form with oblong-lanceolate leaves, concave, almost glabrous above.

Port Lincoln, S.A. S. Dixon, 1883.

PULTENAEA PEDUNCULATA, Hooker.

(Bot. Mag. t. 2859, 1828.)

P. Ausfeldii, Regel in Gartenflora 14 (1865).

Hooker described his species from plants grown at Kew in 1828, from seed sent from "New Holland" by Fraser, Govt. Botanist of

the Colony. Regel described his from plants grown at Berlin in 1865, from seed supplied by Dr. Ausfeldt, from Bendigo, in Victoria.

Unfortunately no type specimen of the former was preserved at Kew; but the plant found commonly in South Eastern Australia—Bendigo included—has been accepted by Mueller, Bentham and others as tallying sufficiently with Hooker's description and plate.

Let us consider the differences on which Regel founded his species. He says. "*P. pedunculata* differs from it (a) in having flowers in twos, which, to begin with, arise at the tips of the branches, and only later are pushed to one side." Hooker's description of *P. pedunculata* says: "Flowers in pairs from the extremity of the young branches, but they afterwards become lateral from the prolongation of the branches." *P. Ausfeldii* has "axillary flowers." On all specimens from Bendigo district I find a number of young branches showing flowers two, and sometimes three, together at the ends. As these become lateral from the prolongation of the branchlets, they show as axillary, and a close examination of the pairs shows them to be axillary from the first, but much crowded, so that Hooker's description is not incompatible with "axillary flowers." When becoming lateral, they do not remain so close as to be considered twin flowers. May we presume that Hooker appears to have laid stress on the earlier stage, while Regel appears to have ignored it? (b) Regel says, quoting from Hooker, "Flower-stalks one inch or more." We have specimens from Port Lincoln with peduncles about one inch long, and except for rather broader leaves, tallying in every other respect with the Bendigo specimens. I scarcely think that a species should be founded on that difference only. (c) "Zig-zag lower branches." Just a minor difference of habit. (d) "Only pointed leaves." Hooker's description omits any reference to the points on the leaves. His plate shows them only pointed, but the omission in his description does not mean that the "sharp thorny tip" mentioned in Regel's description was not present. (e) "Not united stipules." Hooker's description says: "two brown membranous stipules which stand upright, and are appressed to the stem." That does not mean that they are not partly united when at or near the ends of young branches, among crowded leaves. In the Bendigo specimens they certainly are so, but I find pairs of broad, membranous stipules showing exactly as in the Bot. Mag. plate. Lower down, I find stipules quite disunited. It should be remembered that right through the genus examples may occur where, on the same specimen, within a range of a few inches, stipules are: "broad, reddish, scarious, appressed and united," and "narrow, recurved, blackish and quite disunited." (f) "Erect calyx lobes." Hooker's description does not say so, although the plate shows some lobes scarcely spreading. I am of opinion that the plate drawn in 1828 represents, rather incorrectly, the plant grown at Kew from seeds from the form accepted by Bentham and Mueller as *pedunculata*, growing from Port Jackson to Spencer Gulf, and that Regel described his species from a plant grown from the same seeds, i.e., that both lots of seeds were from the same species. Dr. Stapf, of Kew, in a report to the

Director, Dr. Prain, says:—"There can be little doubt that certain specimens enumerated in the Flora Aust., under *pedunculata* represent *P. Ausfeldii*, especially those from 'Windu Valley, Robertson,' 'Bugle Range, Mueller,' (Mueller Exped. 1838). 'Belair,' (931), 'Koch.' Unfortunately no specimen of *P. pedunculata* was laid down at the time when the species was described, and I have failed to identify any of our specimens written up as *P. pedunculata* with the Bot. Mag. plate." Dr. Prain, commenting on this last statement, says: "This may either mean that the Bot. Mag. figure is not correctly drawn, or that the plant which flowered at Kew in 1828 was a member of the same group of forms, but one that has never been met with again." It will be seen that I have decided in favour of the former of these possibilities. Copies of descriptions, figures and comments thereon kindly sent from Kew have helped me considerably in discussing this difficult matter. Two forms divergent from the type may be noted as varieties:—

Var. *pilosa*, var. nov.

Variat calyce et pedunculis sericeo-pilosis, foliis paulo recurvatis.

A form with silky hairs on calyx and peduncles, and leaves somewhat recurved at the tips.

Chewton, near Bendigo, Vic. (Coll?)

Var. *latifolia*, var. nov.

Variat foliis oblongo-lanceolatis, bracteolis calycis lobis longo-subulatis pedunculis pollicem longis.

A form with oblong lanceolate leaves, long-subulate calyx lobes and bracteoles and peduncles an inch long.

Port Lincoln, S.A. (Coll?)

PULTENAEA CUNNINGHAMII, (Bth) F. v. M.

(*Spadostyles Cunninghamii*, Bth. in Ann. Wien Mus. ii. 81, 1838; *Pultenaea ternata*, F. Muell. Fragm, 1, 8, and iv, 21, 1858.)

The combin. "*P. Cunninghamii*" was suggested by Mueller in Fragm. iv. 21, as a name for *P. ternata* and *P. styphelioides* if united, so we may accept the suggestion except as regards the inclusion of the latter plant.

A shrub usually glabrous, often glaucous, with sessile leaves all in whorls of three, broadly rhomboidal, truncate or shortly tapering, the midrib produced into a sharp thorny point, 2 to 9 lines long, usually broader than long, often 3 to 5 nerved at the base, with flowers in axils on pedicels 2 to 3 lines long, with bracteoles narrow-lanceolate or linear, subulate, inserted on the base of the calyx. Calyx 3 to 5 lines long, with lower lobes longer than the tube, upper much broader, united above the middle. Ovary glabrous, tapering into a flattened style.

Vic.: Buffalo Mts., Mitta Mitta, Whitfield. N.S.W.: Blue Mts., Narrogas; source of Hunter R., Carter; Mudgee and Gilmore, J. L. Boorman; Port Jackson.

Specimens gathered at Whitfield, N.E. Vic. by myself, have flowers and leaves of the largest size.

Var. *pubescens*, Bth.

A small-leaved form, with branches more or less pubescent, and flowers on shorter pedicels.

Vic.: Upper Murray, and Mitta Mitta. N.S.W.: Hunter and Clarence Rivers. Queensland: Helidon, F. M. Bailey; Darling Downs, with large leaves, H. Law.

PULTENAEA SPINOSA (D.C.) comb. nov.

Oxylobium spinosum, D.C., Prod. ii. 104, *Euchilus cuspidatus*, F. v. M. Trans. Phil. Inst. Vic. ii, 68, *Pultenaea, ternata*, F. v. M. var. *cuspidata*, Bth. Fl. Aust. ii, 122.

"Branches slender, pubescent, leaves small, tapering into a pungent point."

Qld.: Burnett and Brisbane Rivers, F. Mueller. Wide Bay, Bidwill. Ipswich, Nernst. Enoggera, C. T. White, Mar. 1922. N.S.W.: Clarence River.

This plant is sufficiently distinct to rank as a species owing to its very small much tapering leaves with long, straight points, its long peduncles, and very small flowers with sharp points on calyx lobes.

This and *P. Cunninghamii* appear to be extremes of a series of intermediates, the position of which will not be easy to determine, but an attempt must be made to do so. We must agree with Messrs. Maiden and Betche, who point out, (Proc. Linn. Soc. N.S.W. XXXIII. 310), that we must draw arbitrary lines where series of intermediates occur, and that if we were to unite all species between which connecting links exist, we would reduce many large genera to only a few species, which would be neither practicable nor expedient.

PULTENAEA KENNYI, sp. nov.

Frutex circiter 30 cm altus, ramulis pubescentibus, foliis truncatis 5-9 cm longis, 3 mm latis breviter petiolatis planis vel margine paululum recurvatis mucronulo recurvo terminantibus supra glabris infra exigue minutissime pubcrulis, stipulis 1 mm longis, floribus solitariis prope apicem ramulorum axillaribus, pedicellis sericeo-villosis 2 mm longis, bracteis nullis, bracteolis circiter 1 mm longis, medio calycis affixis, calyce 5 mm longo lobis tubo aequilongis superioribus falcatis albo-sericeo-villoso, vexillo et alis flavis, carina sordide flavescente, ovario sericeo-villoso, stylo subulato, legumine non viso.

Shrub about 3 ft. high, similar in appearance to *P. retusa* Sm. Leaves 3-4 lines long, truncate, slightly recurved at the margin, the midrib ending in a minute recurved point, glabrous above, but with

a few silky hairs below. Flowers solitary in the upper axils with no bracts. The bracteoles are about half a line long, and are fixed high on the calyx tube.

This plant belongs to the Section *Eupultenaea*, and in foliage reminds one of *P. retusa* Sm. Only three other plants in the Section have flowers not in terminal heads, viz., *P. conferta* Bth., *P. Millari* Bail. and *P pedunculata* H.K. The first-named is easily distinguished by its peculiar calyx with its free upper lobes. *P. Millari* differs from the new plant in having larger, almost ovate leaves with a dense, silky tomentum beneath, and in its larger stipules, a flattened style, hairy from below upwards, and long bracteoles, fixed at the base of the calyx.

Crow's Nest, on the Northern Darling Downs, Southern Queensland. Dr. Frederick Hamilton Kenny, Feb. 1922.

Dr. Kenny, after whom the plant is named, is an enthusiastic botanist, and was accompanying Mr. C. T. White, F.L.S., Government Botanist of Queensland, on a botanising trip when the plant was found.

PULTENAEA TERETIFOLIA, sp. nov.

Frutex parvus, ramulis pubescentibus, foliis tenuissimis lineari-cylindricis supra canaliculatis puberulis vel hispidulis 8-12 mm longis, floribus breves ramulos terminantibus in capitula confertis, stipulis subulatis, bracteis nullis vel paucis brevibusque, bracteolis linearibus villosis tubo calycis aequilongis eoque ad basin affixis, calyce pubescente canescente lobis acutis tubo subaequilongis superioribus latiusculis quam inferiora, ovario villoso, stylo subulato.

A shrub with very slender terete leaves minutely hispid, and with a light coloured calyx and linear ciliate bracteoles.

South Australia: "Murray Scrub," Spencer Gulf (Coll?), Warunda, near Port Lincoln, Griffith. Kangaroo I., O. Tepper. Marble Range, Wilhelmi.

This plant has been included by Bentham under *P. mollis* Lindl. as "var. *canescens?*" p. 128, Fl. Aust. The query mark shows that he was doubtful. It should rank as a species, being well away from *P. mollis* in indumentum, inflorescence and bracteoles, which latter are linear ciliate not keeled. It is nearest to *P. canaliculata* F. v. M. under which written name indeed one specimen was placed as a variety by Mueller in his herbarium. Its fine leaves, hispid, not silky, its flowers capitular crowded, and short bracteoles fixed on the calyx, not under it, keep it distinct from that species.

Var. *brachyphylla*, var. nov.

Variat floribus paucis, petalis atro-rubris, foliis 4mm longis.

A plant with thicker and shorter leaves and fewer flowers and darker petals which has been found labelled "*P. adunca* Turcz."

S.A.: Kangaroo I. and Harriet, O. Tepper.

PULTENAEA D'ALTONII, sp. nov.

Frutex 60-80 cm altus, ramulis pubescentibus, foliis lineari-cylindricis supra canaliculatis subclavatis obtusis divaricatis 4-6 mm longis apice paululum recurvis minute patenti-hispidis, stipulis latiusculis subulatis recurvatis, floribus axillaribus apice ramulorum inter latas stipulas foliorum floralium confertis, bracteolis foliis similibus ad basin calyce affixis latas stipulas scariosas gerentibus, calyce 8 mm longo pilis patentibus pubescente lobis tubo longioribus, superioribus falcatis latioribus et conjunctioribus, ovario sericeo-villoso, stylo usque ad medium villoso, legumine non viso.

Shrub to 3 ft. high, with terete, much spreading, somewhat clavate, minutely-hispid leaves, and with a calyx with much falcate upper lobes and leafy bracteoles fixed to the base of the calyx, and provided with broad scarious stipules.

This plant has been placed under *P. tenuifolia* R. Br. from which it differs in its divaricate, blunt, and somewhat clavate leaves not at all fascicular as in *tenuifolia*. Flowers are not terminal or two together, or enclosed by bracts. Bracteoles are leafy and stipulate, which is not the case in the typical *tenuifolia* of Brown. The calyx is very different, being twice as large, with falcate upper lobes. *P. tenuifolia* has a calyx with almost equal lobes which, when not glabrous, are beset with long, straight white hairs (Port Lincoln specimen, Griffith).

In foliage the plant has a marked resemblance to *P. teretifolia* (above).

It is nearest to *P. laxiflora*, Bth. var. *pilosa*, Williamson, having the same calyx and bracteoles, but there are no bracts except the broad stipules of the floral leaves, and the flowers are sessile in dense clusters, and the leaves divaricate, and hispid with short hairs.

Between Nhill and Goroke, N.W. Victoria, St. Eloy D'Alton, Oct. 1897.

This species is named after Mr. St. Eloy D'Alton, whose records of many years' collecting in the North West of Victoria are a valuable addition to the Botany of that State.

PULTENAEA PROLIFERA, sp. nov.

Frutex erectus circiter 60 cm altus ramulis pubescentibus, foliis linearibus margine incurvatis vel lineari-cylindricis supra canaliculatis 8 mm longis patentibus incurvatis minute hispidis, stipulis subulatis, floribus singulis vel binis sessilibus apice ramulorum brevissimorum, fructibus lateralibus ob proliferum incrementum ramulorum juvenum, bracteis 4-5 imbricatis latis appressis minute pilosis bifidis lobis obtusis interioribus calyce aequilongis, bracteolis oblongis calyce aequilongis infra tubum affixis eumque fere cingentibus, calyce 4 mm longo subglabrescente membranaceo lobis ciliolatis acutis inferioribus tubo aequilongis superioribus brevioribus, vexillo et alis flavis, carina atro-rubra, ovario sericeo-villoso, stylo tenui, legumine lato-ovato villoso.

A shrub to 2 ft. high, somewhat like *P. mollis* Lindl. in foliage, but with leaves hispid with minute hairs. Like *P. tenuifolia* R. Br.,

its nearest affinity, it has flowers in pairs, or singly terminal at the end of very short branchlets, which are proliferous, causing the fruit to appear lateral, but the bracts are not acute, nor twice as long as the calyx, nor glabrous, but have broad, rounded lobes, hairy, and closely imbricate. The calyx, also, is very different, the upper lobes being united almost to the summit. It is an erect shrub with incurved hispid leaves, while *P. tenuifolia* is prostrate, and has straight and almost glabrous leaves.

Carlisle River, Otway Forest, Vic. Miss Sceaney, Nov. 1906, and Willie Lucas, Nov. 1921.

There is a fruiting specimen from the same district labelled in Mueller's handwriting; "*P. mollis*, var. Heaths between the Gellibrand R. and Curdie's River, Mar. 1874."

PULTENAEA BOORMANII, sp. nov.

Frutex erectus, ramulis puberulis, foliis lineari-cylindricis supra canaliculatis 7-12 mm longis appresso-pilosulis in mucronem recurvulum desinentibus, stipulis lineari-setaceis recurvatis, floribus paucis prope apicem ramulorum axillaribus, bracteis nullis, bracteolis lineari-subulatis calyce aequilongis stipulas setaceas ad basin gerentibus tubo affixis, calyce 9 mm longo villoso lobis subulatis 7 mm longis superioribus paululum latioribus, ovario glabro, ad summum cirrum album gerente, stylo subulato, legumine non viso.

An erect shrub to 2 ft. with very slender terete leaves and axillary flowers with a remarkably short calyx tube, and with stipulate bracteoles fixed at the base of the calyx.

In foliage this species resembles *P. mollis* Lindl. but it has flowers axillary, and not in terminal heads. It must be placed in subsection F. of Sect. *Coelophyllum*, between *P. humilis* and *P. setulosa*.

It resembles the former in its long narrow calyx lobes and its glabrous ovary surmounted by a tuft of white hairs, but differs from it in having very slender terete leaves, and stipulate bracteoles set higher on the calyx tube. *P. setulosa* with its fine points to leaves, stipules and calyx lobes, and its longer calyx tube, can be easily distinguished from this species.

It is named after Mr. J. L. Boorman, who first collected it.

Mr. Cheel, Chief Asst. to the Government Botanist, Sydney, has supplied the following notes on the plant:—

"It was originally collected at Minore, N.S.W., by Mr. J. L. Boorman, in Feb., 1899, and was determined by the late J. H. Camfield as a doubtful form of *P. echinula* Sieb. In 1904, some additional specimens were collected at Bidden Road, 7 miles from Gilgandra, North of Dubbo, by Mr. R. H. Cambage, who sent them in under No. 1110, Oct. 15, '04, as a doubtful form of *Dillwynia ericifolia*. Duplicates of the same plant from the same locality were sent in later by Mr. Cambage. These were determined by the late Mr. Betche as *P. mollis*, Lindl., and recorded in the Proc. Linn. Soc. of N.S.W., Vol. XXX. p. 360, as new for N.S.W. In August, 1908, Mr. Boorman collected a small specimen at Goonoo, near Mudgee, and again in June, 1909, from the same

locality, with the following note: "A small, bushy plant, 1-2 ft. high, growing in dry places in forest land. No flowers hitherto met with. Identical plants found at Nundle, and at Warialda." Later, Mr. Cheel, in sending in his report on a specimen sent to me, gave his opinion that it was not *P. mollis*, but an undescribed species, and it was arranged on the advice of Mr. J. H. Maiden, that I should describe the plant.

PULTENAEA READERIANA, sp. nov.

Frutex circiter 1 m altus, ramulis pubescentibus, foliis ovato-lanceolatis vel subcuneatis patentibus. 5-10 mm longis margine paululum incurvatis molle patenti-villosis, petiolis 1.5 mm longis, stipulis subulatis recurvatis vel appressis latioribusque in ramulis junioribus, floribus 3-5 breves ramulos terminantibus in capitula foliosa confertis, bracteis nullis praeter latas stipulas foliorum floralium, bracteolis linearibus ciliatis tubo calycis subaequilongis interdum stipulas gerentibus, calyce 4-5 mm longo pubescente, lobis acutis tubo longioribus, inferioribus angustioribus, ovario sericeo-villoso, legumine non viso.

A shrub about 3 ft. high, with leaves ovate-lanceolate to almost cuneate, much spreading, about two lines long, on very distinct petioles, slightly incurved at the margin, and beset with soft spreading hairlets. Flowers are in terminal leafy heads, 3 or 4 together on the very short branchlets. The broad stipules of the floral leaves take the place of bracts, and the bracteoles are linear, beset with hairs, nearly as long as the calyx lobes, fixed at the very base of the calyx tube, and occasionally provided with scarious stipules. The calyx is about two lines long, with narrow acute lobes, membranous, and beset with hairs. The ovary is quite covered with silky hairs.

This plant has been wrongly determined as a form of *P. villosa* Sm. In foliage it resembles that species, but its flowers are all terminal, its calyx a very different shape, not being falcate, and its bracteoles are not leafy, as in *P. villosa*. Its nearest ally is *P. hispidula* R. Br. from which it differs in not having a very small calyx with short lobes and long bracteoles.

Southern Grampians, Vic., Nov. 1907, H. B. Williamson. No. 1369. Merton, Vic. A. W. Howitt, No. 974.

Some specimens collected in the Dandenong Ranges and determined as *P. villosa* are referable to this species.

. Named in memory of the late F. M. Reader, who first examined the plant at my request in 1907, and who was well-known as an enthusiastic and careful botanist, who did much valuable research work on the flora of Victoria, especially in the Mallee District.

PULTENAEA BARBATA, C. Andrews.

(Journal, W.A. Nat. Hist. Soc., No. 1, p. 38, 1904.)

An erect shrub of two feet with virgate branches, glabrous or slightly silky when young. Leaves alternate or scattered, narrow-linear, 3-5 lines long on very short petioles, minutely hispid and tuber-

culate, with closely revolute margins. Stipules suppressed. Flowers in heads or umbels apparently terminal, but with a short leafy shoot slightly exceeding the flowers in the middle of the umbel. Pedicels very short. Bracts not apparent even in the bud. Bracteoles linear-lanceolate, villous, persistent, inserted under and free from the calyx, 2-2½ lines long. Calyx silky, villous, 2-2½ lines long, the three lower lobes slightly longer than the tube, subulate, the upper lobes broader, and united higher up. Standard 3 lines long, broad, dark-brown. Wings slightly shorter and similar in colour. Keel obtuse, slightly incurved, yellow. . Ovary villous, tapering into a long incurved style, of which the lower part is villous all over, and the upper part glabrous except for the fringe of white silky hairs on the inner side. Pod not seen.

This species belongs to the section *Eupultenaea.* The habit, foliage, and style are like those of *Phyllota barbata*, Benth., but it has the free stamens and strophiolate ovules of *Pultenaea.*. Its nearest ally is perhaps *P. pinifolia*, Meiss., from which it differs in shorter leaves, absence of stipules, persistent bracteoles, narrow calyx lobes, smaller flowers and peculiar style.

In flower, October, 1903, near Phillips River, W.A. Andrews.

The above is taken from the Journal Nat. Hist. Soc. W.A. I have not been able to ascertain where the type specimen of the plant was placed, if indeed it was preserved at all.

It would be well if the rule:—"That for a species to be recognised, the type must be deposited in some leading Botanical Institution of the country in which it is gathered." were always followed.

PULTENAEA ARIDA, E. Pritzel.

(Engler's Bot. Jahrb. Bd. XXXV. 258, 1905.)

"Shrub 20-30 cm. high, with opposite spreading branches, sometimes spinescent, the young branches hoary-pubescent. Leaves opposite or ternate, very shortly petiolate, 3-5 mm. long, 2 mm. broad obovate, or almost truncate, obtuse, nearly flat, densely and finely silky pubescent. Stipules small and brown. Flowers 1-3 in axils on pedicels of 3 mm. long. Bracteoles dark-brown scarious, very small and adnate to the calyx. Calyx silky, with a very short tube, upper lobes much broader and longer than the lower."

I have examined a piece of the type which the authorities of the Berlin Museum of Botany kindly sent along, and I find the bracteoles fixed well below the calyx. The plant comes between *P. obcordata* Bth., and *P. rotundifolia*, Bth., from which two species it differs in its rigid spinescent branches, length of pedicels, size and indumentum of leaves and shape of calyx.

PULTENAEA SUBALPINA, (F. v. M.), Druce.

(2nd. Suppl. Bot. Exch. Club Report, 1916, p. 643.)

This is *P. rosea* of Mueller, who described the plant under the name *Burtonia subalpina* (Trans. Phil. Inst. Vic., i., p. 39, 1855), and

afterwards removed it to the genus *Pultenaea*, giving it the appropriate and euphonious species name *rosea*, which, however, was corrected by Druce as above, in accordance with the Vienna Rules.

PULTENAEA HIBBERTIOIDES, Hooker, f.

(Fl. Tasm. i., 89, 1860.)

A shrub with branches and leaves of *P. mollis*, Lindl., and inflorescence very similar, but differing from that species in having imbricate bifid bracts, the inner ones over two lines long, and usually striate. The bracteoles also, are different, being at least as long as the calyx, and fixed distinctly under the tube, not upon it. The calyx lobes are not so short, being as long as the tube, and acute or acuminate. From *P. viscosa* it differs in having narrower terete leaves, larger bracts, etc.

Vic.: Buffalo Mts., Mueller, Mt. Hotham, and other parts of the Alps. N.S.W.: Aust. Alps. Tas.: Between Launceston and George Town.

Var. *conferta*, Bth.

Pedicels short, bracts and bracteoles smaller. "Australia felix," Mueller.

I have not seen Mueller's specimens, but specimens from Cobden, S.W. Vic. (Coll?), I have determined as this variety.

PULTENAEA MOLLIS, Lindl.

(Mitchell's Three Expeditions ii., 260, 1838.)

A shrub with branches clothed with soft hairs, and having terete or narrow-linear leaves ½ to 1 in. long, which are also covered with soft, appressed hairs. Flowers are in terminal heads, each on a pedicel of a line long. The calyx lobes are broad, shorter than the tube, and all nearly equal. Bracts are short, and few besides the broad bract-like stipules of the floral leaves. Bracteoles are lanceolate, keeled, and set on the base of the calyx tube, from one-half to nearly the length of the calyx, thin, shining or viscid, and ciliate at the edges.

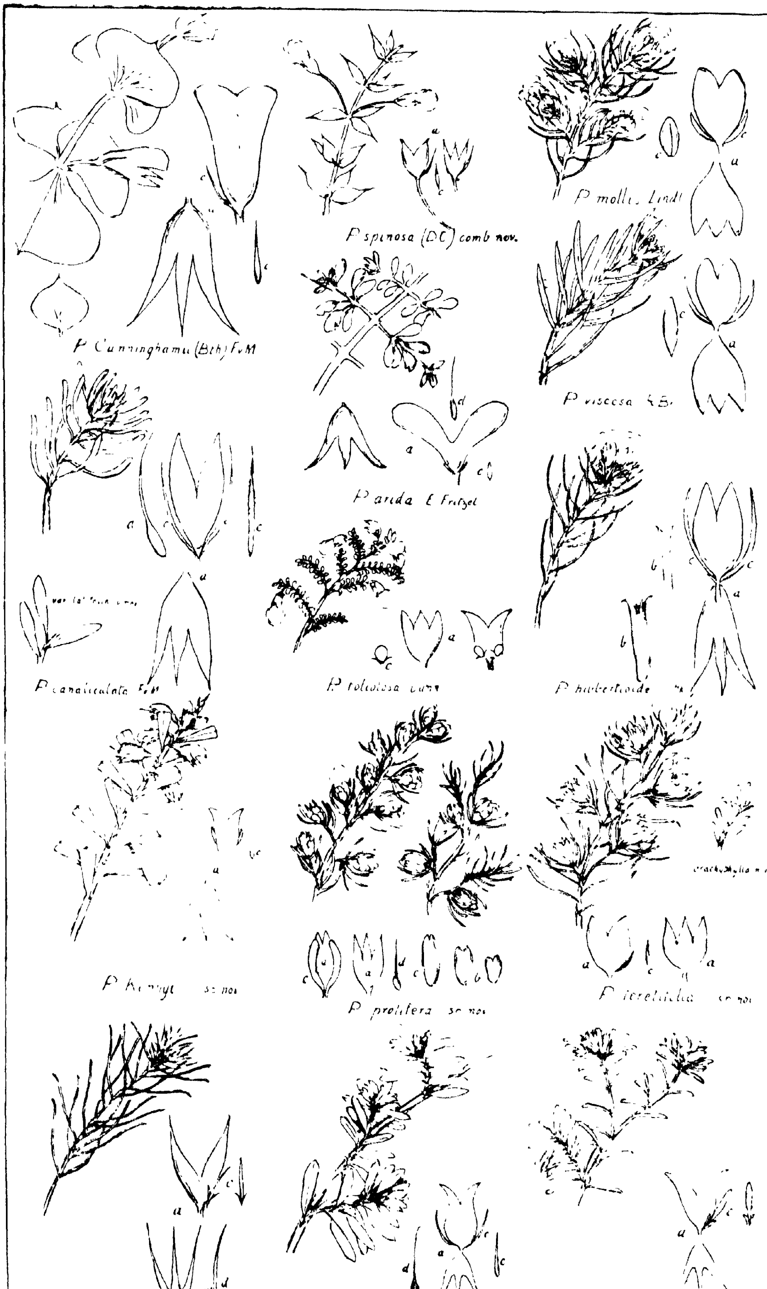
Vic.: Mt. William and Wannon River, Grampians.

Specimens from Mt. Macedon and the Dandenong Ranges differ from the type in having almost glabrous leaves, smaller and less hairy calyx with very short lobes, and with broad and very short bracteoles.

PULTENAEA VISCOSA, R. Brown.

(Bth. Fl. Aust., ii., 127. 1864.)

A shrub to 4 ft. resembling *P. mollis*, but with leaves constantly open on the upper side, and sometimes nearly flat, with midrib showing distinctly both above and below. The flowers are more crowded in the heads than those of *P. mollis*, and the pedicels are shorter. It differs also from *P. mollis* in having larger bracts and bracteoles, which latter are fixed under the calyx, and are not ciliate. No speci-


P. Cunninghamii (Bth) F.v.M
P. spinosa (DC) comb. nov.
P. mollis Lindl
P. viscosa R.Br.
P. arida E. Pritzel
P. canaliculata F.v.M
P. prolifera sp. nov
P. Reederiana sp. nov
P. D'Altonii sp. nov
HBW del

mens that I have seen seem to deserve the name "*viscosa*," which certainly would fit the calyx of some specimens of *P. mollis* from the Grampians.

N.S.W.: Parramatta, (type), Clyde Mts., Wombaya Ra. Vic.: Southern Grampians; Portland.

The specimens from Portland, and some from the Grampians vary from the type in having shorter and more incurved leaves almost closed on the upper surface.

Much confusion has existed regarding these last three species, Mueller himself having labelled as "*P. mollis*," specimens from the Buffalo Mts., which are undoubtedly *P. hibbertioides*. And between *P. viscosa* and *P. mollis*, the same confusion has arisen.. Robertson's Mt. Sturgeon specimens (p. 127, Fl. Aust.), which Mueller and Bentham both considered as *P. viscosa*, are not available, but it is probable that the specimens I sent to Mueller in 1898 from Mt. Sturgeon, and which he determined as *P. viscosa*, were from the same plants as Robertson found, and yet we have specimens from the same locality, gathered by Mueller himself apparently from the same bushes, labelled "*P. mollis*, Lindl." and initialed by Bentham.

Some must be wrong, and I suggest that the name *P. mollis* be kept for the plant with very slender leaves, from the Grampians, Dandenongs, and Macedon. In all these the bracteoles are broad and keeled, and fixed below the calyx, not on it. In no specimen written up as *mollis* have I found the bracteoles narrow. However, until we ascertain where Lindley's type specimen is to be seen, we shall still be in doubt as to what plant is *P. mollis*. With regard to *P. viscosa*, my opinion is that we have in the Grampians the normal plant with almost flat leaves as in the Parramatta specimens, and also a variety differing only in the shorter and more incurved leaves.

There are two other recognised species, *P. styphelioides*, A. Cunn. and *P. procumbens*, A. Cunn., which cannot be safely dealt with without reference to type specimens, and they are not at present available in Australia. Quoting the words of Messrs. Maiden and Betche in a paper dealing with the doubtful position of certain forms of *P. microphylla* (Proc. Linn. Soc. of N.S.W., Vol. 38, 1908, p. 311), I believe that:—"In doubtful cases we can only record our difficulties, and honest and careful expression may have value even if they prove erroneous, since they will help to a better understanding of the flora."

EXPLANATION OF PLATE VII.

Leafy branches, nat, size.
(a) Calyx lobes x 2.
(b) Bracts x 2.
(c) Bracteoles x 2.
(d) Ovary and style x 2.

[PROC. ROY. SOC. VICTORIA 35 (N.S.), PT. I., 1922].

ART. IX.—*Two New Species of Bryozoa.*

By W. M. BALE, F.R.M.S.

(With Plate VIII.)

[Read 13th July, 1922.]

The two species of Bryozoa to be described belong to the series of forms included by Busk in the genus *Catenicella*. The members of this genus are among the most abundant of the Bryozoa which are found on our beaches, and are known to seaside visitors as "curly seaweeds." Nearly all of them are found in Australia, and but few elsewhere; none at all in the Northern Hemisphere. In MacGillivray's Catalogue of recent Victorian Polyzoa are comprised about 35 species, including those separated by him under the name *Claviporella*. The greater number of species were originally described by Busk, others have been added by Wyville Thompson, MacGillivray, Maplestone, and Wilson. Many fossil forms were described by MacGillivray and Maplestone in the publications of this Society, some of them identical with recent forms.

More recently Levinsen has dismembered the group, assigning a number of new generic names to many of the species, and adopting for the rest the name *Catenaria* instead of *Catenicella*. Whether all Levinsen's genera will be accepted is uncertain; for the present I retain the old classification as given in MacGillivray's Catalogue.

The two species before us were handed by me to Mr. Bretnall, of the Australian Museum, the only Australian zoologist known to me to be now working on the Bryozoa. Mr. Bretnall intended to describe them, but, unfortunately, illness, the result of war injuries, has temporarily interrupted his work, so I have undertaken the task.

Our first species is a very interesting one. It was among a quantity of material sent to me by Mr. E. H. Matthews, of Largs, South Australia, and it was recognised at first sight as different from any of the known forms. The outstanding difference between it and more familiar forms is that the alae or lateral expansions of the zooecia are perfectly clear and uncalcified, contrasting strongly with the darker more opaque substance of the remainder of the cell. Comparison with other species, however, shows instances of similar structure, though to a far less extent. In *C. plagiostoma* and *C. intermedia*, for example, that portion of the alae which is at the top of the zooecia seems as free from calcareous matter as in the present species; while in other forms, such as *C. alata*, the alae, though strongly calcified, contain definite areas wholly chitinous.

Mr. Bretnall informs me that in Levinsen's system this species would come under the proposed genus *Pterocella*, or may possibly have to be separated as a new genus. After the discoverer I name it *Catenicella* (or *Pterocella*) *matthewsi*. It appears plentiful at Corny Point, Spencer's Gulf, where Mr. Matthews collected it.

The other species belongs to MacGillivray's genus *Claviporella*, distinguished from *Catenicella* by the keyhole-shaped orifice of the zooecium, and by its obtuse tubular processes. There are only a couple of rough mounts left by Goldstein, and marked in pencil, "*Cat. MacCoyi*, new." Goldstein's general collection of Bryozoa was disposed of in his life-time, and is supposed to have been sent to England, but the slides in question were among a quantity of unfinished material handed to me after his decease. Mr. Bretnall has already pointed out that in Miss Jelly's "Synonymic Catalogue of the Bryozoa," are included several species ascribed to Goldstein, but without any reference. Miss Jelly was assisted by Waters, with whom Goldstein corresponded, and the presumption is that she got these names from him, but it seems extraordinary that Waters should have sanctioned the inclusion in the list of species which had never been described, and especially the reference of two of MacGillivray's published species as synonyms of these nomina nuda. *C. MacCoyi* was one of the names included, and it will now be accounted for as *Claviporella goldsteini*. Possibly some of the other species may be identical with those since described by others.

In passing, I should like to add a few words on the methods of preparing and mounting these polyzoaries. Too often they have been described from examples of the dry material only; MacGillivray's specimens, except a few special ones which were mounted in fluid, and which have gone or are going, the way of all fluid mounts, are mounted dry. This method is in some cases incapable of showing all the detail. For example, there are two species, *Thairopora jervoisi* and *Diploporella cincta*, which contain numerous minute spicules, the former species especially having them in great profusion, and very evident in balsam mounts, yet the friend to whom I showed them —though familiar with the species for many years as a dry mount— was not yet aware of their existence. Similar insufficient methods have been responsible for the descriptions of "openings" in the alae of various species, which are really only clear areas, and minute avicularia have sometimes been overlooked. The method which I have been accustomed to use in mounting polyzoaries and polypidoms is to boil them in water till all air is removed, transfer them to methylated spirit, thence to phenol, and thence to balsam. For clean specimens this suffices, but if very dirty they should be first heated in liquor potassae to remove foreign matter. This is also useful for swelling out tissues, which have shrunk in drying; for example, it is often impossible to decide whether the chitinous alae have openings in them when they are shrunk together. As mentioned further on, also, it is often desirable to decalcify and stain. Liquor potassae is sometimes too strong, and acetic acid may give better results, but of course it is only available when decalcification is desired.

Catenicella matthewsi, n. sp. (Plate VIII., Figs. 1a-1f).

Colonies about an inch in height, much branched, branches always springing from geminate zooecia.

Zooecia elongate oval, with about 11-13 small round fenestrae with fissures converging to a minute sub-oral pore. Orifice semi-elliptic, contracted at base, with two lateral teeth. Avicularian processes long and narrow, at angles of about 45° with the axis, avicularia terminal, very minute. Alae very large, not calcified, hyaline, apparently structureless.

Ooecium galeate, terminal on one of the cells of a geminate pair; orifice transverse, wider than high, below the lip two long, linear, widely divergent fenestrae with three or four small round ones.

Type in the National Museum Collection.

This is a remarkable species, which it is impossible to mistake for any other, owing to the unique character of the alae. The zooecia are oval, more convex behind than in front; at the back they appear somewhat barrel-shaped, in front they are more ventricose, and in the lower half is a thin lateral extension on each side with a convex outer border, more conspicuous after decalcification. The zooecia at the ends of the side branches are commonly rather narrower than the others, and possess narrower alae.

The orifice is rather large, semi-elliptic, but with the sides becoming convergent near the base, and at the points where the convergence begins there are two lateral teeth. The lower side of the orifice is somewhat convex, and below it is a minute pore, connected with the lip by a straight fissure. The operculum is of similar form to the orifice; its rim is slightly thickened, with an enlargement just at the points subtending the lateral teeth. It has no ornamentation except a vertical bar or median thickening which runs from the top of the operculum downwards for about two-fifths of its length, and is continuous with the rim. The back of the zooecium is plain.

The fenestrae are small, and form an outer series of seven or eight, enclosing a sub-triangular area in which are from two to five others. They are connected by rough-edged fissures with the sub-oral pore.

The avicularian processes form long narrow arms rising from the shoulders of the zooecia, tapering outwards to about the middle, and then enlarging slightly to the obtuse ends. The avicularium itself is very minute (only about 15 μ from base to apex); it is of the usual sub-triangular form, with rounded angles and a thinner median area; the apical tooth generally found in the larger forms is wanting. A similar avicularium is usually sessile in the upper part of the area between the two cells of a geminate pair.

The alae are wide and form the most striking feature of the species. The lower chambers are outwardly convex, and the superior ones are still more so; on the summit of the geminate zooecia especially they form large inflated bladder-like expansions. At the two outer angles of the avicularian process the alae form little prominent points, and occasionally the superior inflation of a geminate pair tends towards a bilobed condition, and may run out into similar points. The most remarkable feature of the alae is the entire absence of calcification or of any perceptible structure; they are therefore only visible by their outline, and by any lines of shrinkage which may be

present. With a pocket lens they are invisible, and the same is the case when they are examined in the microscope between crossed nicols. In the dry specimens they are more or less shrunken, the superior chambers especially being much contracted, but treatment with acetic acid or liquor potassae plumps them up and removes shrinkage marks, restoring them to what I suppose to have been their original condition. They have no external openings nor specialised areas.

Only four ooecia were seen. In each case they were at the end of a small side branch springing from the older part of the shoot, where the ramification was sparse. The ooecium is geminate with a zooecium, which is not necessarily terminal. The orifice is quite unlike that of the zooecia, being widened laterally and narrowed to the ends, its form is accentuated by its being seen foreshortened owing to its position in the lower part of the pear-shaped ooecium. Below it are two long, widely-divergent fenestrae, with three or four minute round ones. There is a sub-oral pore. The ooecial chamber is a densely cribrose structure, opaque and strongly calcareous. It is encircled by a band, plain below, undulated above, the median undulations being extended upwards into vertical bands reaching the top of the ooecium, the back band being very wide, the front one less so. In one case there was also a very narrow lateral band. The bands are very finely granular, and resemble a veil overlying the coarse structure. On the summit of the ooecium are two short obtuse processes surrounded by a slight chitinous web. From analogy it seems likely that these processes may support avicularia, but I was not able to discover any.

Decalcification with acetic acid, by removing the semi-opaque material from the sides of the zooecia and the avicularian processes renders the whole transparent, and makes them as clear and structureless as the alae. It leaves the tissues somewhat flaccid, so that many of the zooecia become more or less crumpled; this, however, is not material, as some of the cells, especially the older ones, retain their shape sufficiently, except that the back shrinks a little. The only points of structure which I observed to become wholly obliterated were the fissures which converge from the fenestrae towards the suboral pore; these are evidently confined to the calcareous layer, as they disappear completely. The fissure connecting the suboral pore with the orifice is not affected. But though the alae and the body of the cell are thus made to appear alike hyaline and structureless, they seem to be of different composition, as they reacted differently to a staining process. The stain used was an anilin "indigo-blue," mixed with acetic acid, and giving a blue or green stain varying according to proportion. Ordinarily the corneous joints between the cells, normally a deep yellow, came out an intense green, as did the tendrils which spring from the back of some of the cells. The zooecia themselves, with the avicularian processes (that is to say, all parts which had been originally calcified), were also green, while the alae, as well as the fenestrae, became bright purple.

There are two species which are allied in many respects to the present, though differing widely in their general aspect from it, and

also from each other; these are *C. alata* and *C. carinata.* Apart from mere differences in the form of the zooecia, and of the alae, the structure of the latter is very distinctive. In *C. alata* they are far wider than in our species, in *C. carinata* they are narrower, but in each case they are strongly calcareous, though presenting several large, clear spaces, which have been described by Busk, MacGillivray and others as "openings," but which are really areas wanting the calcareous layer. They may be aptly described as "fenestrae," and just as the small fenestrae on the front of the zooecia usually have fissures (in the calcareous layer only), proceeding from them towards the orifice, so these large fenestrae have similar fissures. The most important distinction, then, between these two species and *C. matthewsi* is that in the former the alae possess certain limited areas of an uncalcified hyaline substance, while in the latter the whole of the alae are similarly constituted.

All three species agree in the possession of the very long avicularian chambers, with the minute avicularia seated on their obtuse extremities. Thompson and Busk mentioned these little avicularia in *C. alata;* in *C. carinata* Busk failed to find them. As, however, he described the avicularian chambers as open in front, which is not the case, it appears likely that he may have observed corroded specimens. The avicularia seem to be readily lost in this species; in the only specimen which I have available only two or three remain. In my slide of *C. alata*, on the other hand, containing a great number of zooecia, almost all are intact. So far as I can judge, the avicularia in these two species are alike; as they are all edgewise in the slides, however, I cannot make out their exact form; but they seem to me to have the angles more rounded, and, therefore, to approach more nearly to a semi-circular form, than those of *C. matthewsi.*

The orifice in *C. alata* does not differ much from that of our species, that of *C. carinata* is so concave below as to approach the circular form, but in both species the lateral teeth are present, and in both the operculum has the vertical bar more or less distinct.

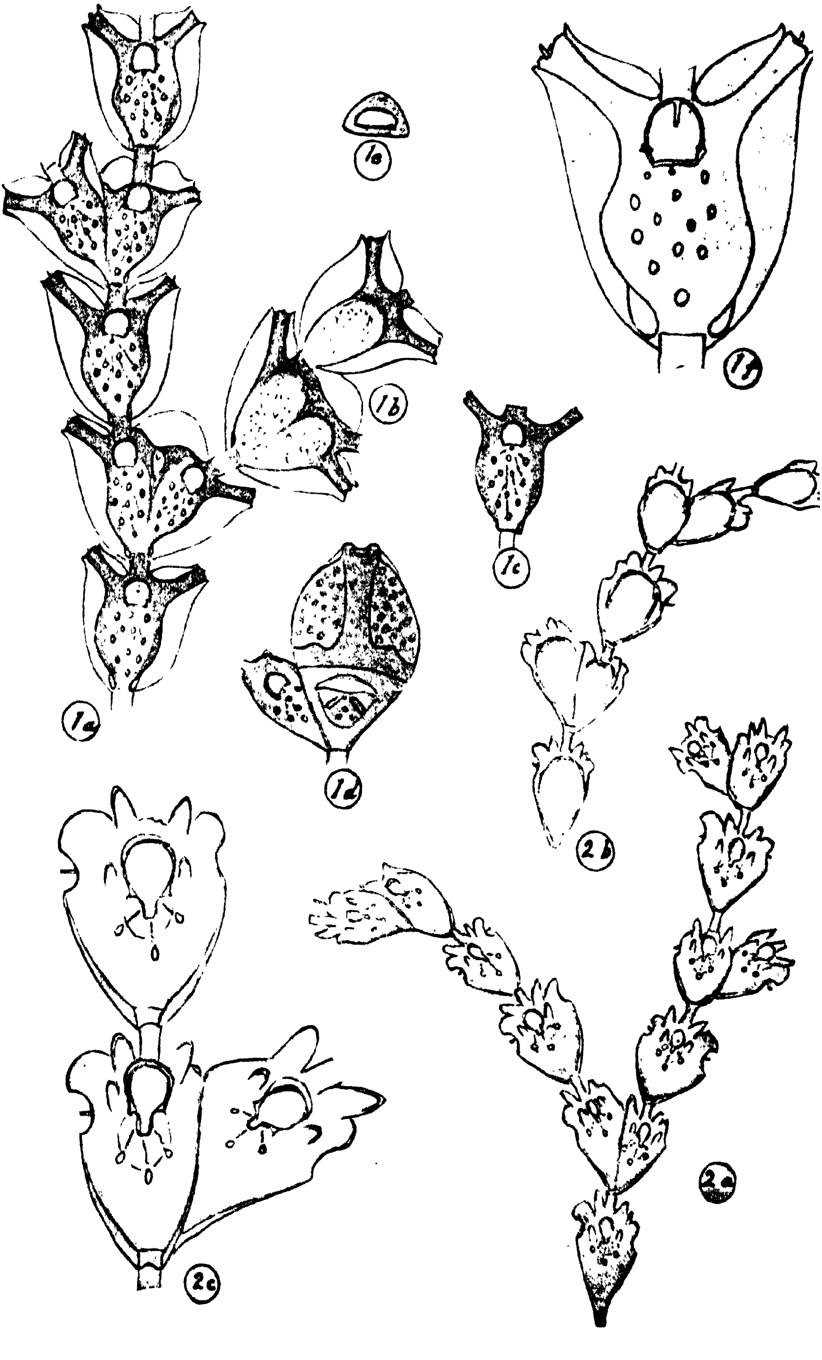
The ooecia of *C. alata* and *C. carinata* are very similar, they agree in possessing a modified zooecium sessile on the top of the ooecium; in this respect they differ from the species before us.

CLAVIPORELLA GOLDSTEINI, n. sp. (Plate VIII., Figs. 2a-2c).

Catenicella maccoyi, Goldstein, nomen nudum, Jelly, Synonymic Catalogue of the Bryozoa.

Shoots very small, branches springing from geminate cells, but also occasionally from the side of a single cell.

Zooecia oval, with a large gaping avicularium on each side, generally unequal, a small rounded, slightly thicker, sub-oral area embracing the inferior prolongation of the orifice; a pseudo-pore surrounded by three minute but distinct fenestrae, all connected with the orifice by rough-edged fissures; a prominent obtuse process at each side of the orifice and two larger ones above; front papillose, back without conspicuous markings, nearly smooth.


1a
1e
1b
1f
1c
1d
2b
2a
2c

Ooecia (?)

Type in the National Museum Collection.

The specimens available do not exceed about half an inch in height. In some instances the branches spring from the sides of single zooecia, and there may even be one on each side. This is the character on which Wilson founded the genus *Catenicellopsis*, but it was not deemed valid by MacGillivray, who mentions having met with the same character in *Claviporella*. It is only in a few of the proximal internodes in one of these specimens that it occurs; higher up the typical mode of branching is constant.

There are usually four obtuse processes, as in *C. aurita*. The avicularia are most commonly unequal, but not differing otherwise; sometimes the inequality is considerable, but there are not in these specimens any of the gigantic forms sometimes found in *C. aurita*.

The ornamentation of the zooecium affords a ready means of distinguishing the species from its allies. In place of the large elliptic pore of *C. aurita* we have here a minute pseudo-pore, often quite indistinct, and the broad band surrounding the pore is here represented by a less distinct circular area. The fenestrae in *C. aurita* are mostly four or five, and somewhat irregular; in our species there are almost invariably three, regularly placed, and though so minute, both the fenestrae and their fissures are sharply defined. This character also distinguishes the species from *C. imperforata* and *C. pulchra*, which latter species, moreover, has an oval central pore and narrower zooecia.

Large circular cavities behind the zooecia are extremely numerous, indicating where tendrils have been detached. The cavities are inside the zooecium, and the tendrils have been broken off flush with the surface, only one remaining. If they all existed at once some of the branches must have fairly bristled with them, but being so brittle it is likely that as new zooecia were produced the tendrils fell from the older ones. In some cases two had existed on a single zooecium.

EXPLANATION OF PLATE VIII.

Fig.	1a	*Catenicella matthewsi*	× 30.
,,	1b	,,	back.
,,	1c	,,	between crossed nicols.
,,	1d	,,	Ooecium.
,,	1e	,,	Avicularium × 400.
,,	1f	,,	Decalcified × 75.
,,	2a	*Claviporella goldsteini*,	× 30.
,,	2b	,,	back.
,,	2c	,,	× 75.

END OF VOLUME XXXV., PART I.

[Published 7th December, 1922].

[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. II., 1923].

ART. X.—*The Occipital Bones of the Dipnoi.*

BY HARLEY S. BAIRD, B.Sc.
(Zoological Laboratory, Melbourne University).

(Communicated by Professor W. E. Agar.)

[Read 10th August, 1922.]

In 1897 Bridge made the statement, "The only endochondral bones in *Ceratodus* are the two exoccipitals." K. Furbringer (1904) draws attention to the fact that Bridge separates these bones sharply from all other bones in the *Ceratodus* skull on the grounds that they are endochondral. Goodrich (1909) accepts Bridge's view of the nature of the bone in the words, "The bone described by Huxley as an exoccipital, the only endochondral ossification in the skull of any Dipnoi, appears to represent the first of the occipital neural arches."

That the exoccipital bone of the Dipnoi is the enlarged first neural arch has been shown by K. Furbringer (1904) for *Ceratodus*, and by Agar (1906) for *Lepidosiren* and *Protopterus*. The reasons for considering it to be an endochondral bone do not appear ever to have been definitely stated. As the question is of some importance in deciding the evolutionary status of the Dipnoi, a histological examination of the bone was undertaken at Professor Agar's suggestion. Well preserved *Ceratodus* skulls were kindly provided by Dr. T. L. Bancroft, of Eidsvold, Queensland, and also by the Director of the Queensland Museum. Comparative material was available in the form of larvæ and young of *Lepidosiren*.

Much depends upon the definition of the term endochondral, which appears to be used in different senses. Adopting Goodrich's classification of the types of bone found in Fishes (1909, p. 63), and which corresponds with Gaupp's nomenclature (1906, p. 610), cartilage bone is of two kinds, perichondral and endochondral. In the former, the bone is deposited layer upon layer by osteoblasts lining the inner surface of the perichondrium (which now becomes the periosteum), thus gradually restricting or replacing the cartilage from outside inwards. Endochondral bone, on the other hand, is formed, not in this, but rather in the opposite way. Spaces are eaten out of the cartilage by osteoclasts, and bone is deposited in the interior of the cavities so formed, and spreads outwards.

Examination of sections of the bone in half-grown *Ceratodus* skulls, and of the development of the bone in *Lepidosiren*, gives no evidence of the formation of endochondral bone in the above sense.

In *Ceratodus* the exoccipital bones are imbedded in the side walls of the chondrocranium. Each is a small hollow bone shaped rather

like an hour glass. The anterior end is slightly more expanded than the posterior, and the whole bone is filled with cartilage (even in the adult), with the exception of the narrow constricted region, where it is bone all through. Transverse sections of one of the exoccipitals from a young *Ceratodus* showed that the ossification was taking place in the periosteum, i.e., it was perichondral. No traces of endochondral bone formation could be observed at all, and since the ossification was very nearly as complete as it ever would be, it seems unlikely that it would occur in a later stage.

The general shape of the occipital bones in *Lepidosiren* is very similar to that of *Ceratodus*, but proportionally they are much larger, as they themselves form the lateral walls for the posterior region of the skull, their anterior surfaces only being in contact with the cartilage of the auditory capsule. They are slightly constricted in the middle owing to their being grooved anteriorly by the vagus, and posteriorly by the first spinal nerve. In the adult *Lepidosiren*, the exoccipital "bones" are very nearly completely ossified, only a small plug of cartilage remains at the dorsal end. Examination of transverse sections of the occipital region at different stages of development indicate that the formation of bone begins in the periosteum, and gradually spreads inwards, upwards, and downwards, replacing the cartilage. As in *Ceratodus* no definite signs of endochondral ossification could be found at any stage.

It would appear therefore that there is not sufficient foundation for the statement that the exoccipital bone in *Ceratodus* or other Dipnoi is an endochondral bone. Such mode of ossification does not seem to have evolved yet in the Dipnoi.

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[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. II., 1923.]

ART. XI.—*New Australian Coleoptera, with Notes on some previously described species. Part 2.*

BY F. ERASMUS WILSON.

[Read 10th August, 1922.]

PSELAPHIDAE.

Genus Rybaxis.

M. Raffray dealing with this genus in Junk's catalogue, after having transferred *electrica*, King, and *lunatica*, King, to *Anabaxis*, records nineteen species from Australia. Mr. A. M. Lea has described a further sixteen species bringing the total up to thirty-five. These, together with the five new species here dealt with, make the genus the third largest of the family in Australia. Having recently had occasion to prepare an up to date catalogue of the Pselaphidae, I find that we have, including my new forms, a grand total of 403 species.

The following three new species are all allied to *strigicollis*, Westw. They belong to Raffray's first group of the genus,[1] i.e., in which the transverse prothoracic furrow is well defined, and the median fovea very small or wanting. They are distinguished from all other Australian species of this group except *strigicollis*, by their curious prothoracic sculpture. Westwood, in describing *strigicollis*, refers to this sculpture as striolate. It consists of very distinct, irregularly longitudinal ridges, frequently running into each other, and thus forming enclosed areas, these being usually more noticeable anteriorly. The above form of sculpture is referred to as strigose in the following descriptions.

RYBAXIS STRIGICEPHALUS, n.sp.

♂ Dark castaneous, appendages and portion of elytra slightly paler. Upper surface clothed with minute pale pubescence, antennae and undersurface with longer pale pubescence.

Head large, slightly longer than wide, lightly narrowed before eyes, somewhat flattened on disc, declivous on sides and between antennae, sides incised about middle for the reception of eyes, these rather prominent, apical three-fourths coarsely longitudinally strigose, basal fourth with a few large punctures particularly at sides, with an obscure fovea on either side of middle at about basal fourth; antennae somewhat slender, joint 1 subcylindric, viewed from above wider than, and about twice as long as 2, 3 and 4, subequal, narrower than

1. Trans. Linn. Soc. N.S.W., 1900, Part II., p. 149.

2, 5 longer and a little wider than 4 or 6, 7 wider than 6, widened internally, 8 much shorter than 7, 9 much longer and wider than 8, 10 larger than 9, 11 about one and one-half longer than 10, lightly bent, bluntly pointed, and with a tubercule about middle on inner side beneath. Prothorax feebly transverse, strongly convex, sides strongly and evenly rounded almost to base, thence very lightly arcuate; base rounded, transversal groove strongly defined, a little widened in middle and terminating on either side in a large fovea; disc in front of groove coarsely longitudinally strigose as on head; behind groove with somewhat sparse but well-defined punctures. Elytra transverse, sides a little sinuate, widest just before apex, apical margin of each elytron a little produced about centre, sutural striae strongly, dorsal rather weakly, defined, the latter traceable to about apical fourth, lightly deflected outwards towards apex, with well distributed but obscurely defined puncturation. Abdomen with puncturation more clearly defined than on elytra, with two medio-basal carinules. Metasternum widely impressed down middle. Undersurface of abdomen armed with two lamelliform protuberances at apex of second segment, these placed near together about the middle, and produced backwards, overhanging the third and part of fourth segments, thence recurved abruptly outwards, their apices rounded; fifth segment greatly constricted in middle, sixth almost wholly occupied by a very large and deep excavation. Legs with femora robust, and anterior tibiae toothed internally near apex.

Length, 2.75 mm.

♀ Similar, but with antennae normal; front tibiae unarmed, non strigose portion of head not punctate, apices of each elytron lightly rounded, abdominal puncturation rather indistinct and undersurface of abdomen convex.

Habitat.—Victoria: Healesville, in moss. (F. E. Wilson). Eltham (C. Oke).

The only Australian species of Rybaxis with strigose head.

Type in author's collection.

RYBAXIS LONGIPILOSUS, n.sp.

♂ Reddish-castaneous, elytra and appendages paler; clothed with long, erect, somewhat sparse pale pubescence.

Head, with apical three-quarters covered on disc with a close meshwork of very large shallow punctures, basal quarter almost impunctate, with a round fovea on either side of middle at about basal quarter; antennae of moderate length, joint 1 rather stout, subcylindric, 3, 4, 5 each lightly increasing in width from base to apex, 3 slightly longer than 4, and 5 than 3, 6 shorter than but slightly wider than 5, 7 a little wider but slightly shorter than 6, 8 subquadrate, much shorter than 7, 9 to 11 forming a moderate club, 11 rather sharply pointed, a little bent and about equal in length to the two preceding joints together. Prothorax transverse, rather strongly convex, sides strongly rounded, widest a little in advance of middle, the two lateral foveae connected by a strongly-defined

groove, much as in the preceding species, in front of groove with disc coarsely longitudinally strigose, behind rather sparsely punctate. Elytra transverse, apical margin of each elytron produced in middle, dorsal striae traceable to about apical fourth, its apex lightly deflected outwards, with sparse moderately defined punctures, epipleural furrow arising from a small round fovea at about basal fourth and terminating a little before apical fourth. Abdomen about width of elytra at their widest part, with two somewhat indistinct medio-basal carinules. Metasternum widely impressed down middle. Intermediate trochanters each with a small tooth. Abdomen with second ventral segment armed at apex with a wide lamelliform protuberance overhanging the third segment, and then abruptly recurved outwards, evenly rounded at apex; apical segment almost wholly occupied by a very large and deep excavation. Legs with front femora stout, front tibiae with an internal tooth towards apex.

Length, 3 mm.

♀ Similar, but tibiae, trochanters and ventral segments unarmed. Undersurface of abdomen convex, but ultimate segment lightly bi-impressed.

Habitat.—Victoria: Ringwood, (F. E. Wilson and C. Oke), Ferntree Gully (C. Oke), Lakes' Entrance (F. E. Wilson).

This species frequents moss growing on the ground in damp situations.

Type in author's collection.

Var. picea.

Size smaller (2.5 mm.). Dark brownish-black, elytra except for a large discal infuscation on basal half (which sometimes extends down the suture), and appendages, dark castaneous; undersurface piceus.

A number of specimens both mature and immature are before me, but though in size and general colouration looking very different from the typical form, I am unable to distinguish any marked character by which to separate them. Some specimens are a little less pilose and a little more nitid than in the typical form, but others again agree very well in these rspects. The immature specimens are wholly flavous.

Habitat.—South Australia: Myponga (A. H. Elston).

RYBAXIS MIRABILIS, n.sp.

♂ Pale castaneous, elytra and appendages slightly paler; sparsely clothed with short pale pubescence.

Head about as long as wide, lightly impressed between antennae, with fairly large and evenly distributed punctures, with two prominent round inter-ocular foveae; antennae with joint 1 a little wider than 2, and about as long as 2 and 3 combined, 3 and 4 subequal, narrower than 2, 5 longer than 4, 6 as long as 5, and slightly wider, 7 shorter, but wider than 6, 8 much shorter, 11 lightly bent, and about as long as 9 and 10 combined, the last three forming a fairly

strong club. Prothorax very lightly transverse, convex, sides strongly rounded to about middle, thence to base very lightly bisinuate, transverse basal groove and lateral foveae as in *strigicephalus*, in front of groove with disc coarsely longitudinally strigose, behind with punctures as on head. Elytra lightly transverse, apical margin of each elytron produced about middle, sutural and dorsal striae well defined, the latter very lightly deflected outwards at their apices; epipleural furrow very distinct, arising from a small roundish fovea at basal and terminating at apical fourth, puncturation well distributed, but somewhat obscure. Abdomen about equal in width to elytra at their widest, with two short medio-basal carinules, puncturation much as on elytra. Metasternum widely and somewhat deeply impressed down middle. Anterior trochanters rather strongly toothed. Undersurface of abdomen with second segment impressed on disc and with two medio apical lamelliform protuberances, these lightly overhanging the following segment and then recurved strongly outwards, their apices rounded, and their bases lightly connected, fourth segment at sides with two subapical lamelliform protuberances directed obliquely backwards, apex of segment straight across middle, and forming the basal margin of a large cavernous apical excavation with straight diverging sides. Legs with femora fairly stout, the anterior ones with a blunt tooth a little nearer base than apex; front tibiae straight, increasing in width from base to about apical fourth, thence suddenly constricted, thus forming a blunt tooth; intermediate tibiae narrower, lightly arcuate and weakly constricted just before apex, hind tibiae much inflated on apical half, and strongly notched close to apex, much excavated on side in neighbourhood of notch.

Length, 3 mm. (vix).

♀ Similar, but a little smaller, with an additional small fovea on disc immediately behind inter-ocular foveae, no armature on femora, tibiae normal. Abdomen beneath convex.

Habitat.—Victoria: Lakes Entrance (F. E. Wilson).

This species, of which I collected ♂♂ ♀♀ from moss growing on the ground, is readily distinguished from its allied species by the remarkable armature of the ♂ ventral segments.

Type in author's collection.

RYBAXIS STRIGICOLLIS, Westw.

This fine species was described in Trans. Ent. Soc. Lond. 1856, p. 269, and a very excellent figure is given in Plate 16, f. 1. It is in my experience a very rare insect. Westwood records Melbourne as the type locality, his specimen having been taken in association with ants. My unique example was secured from a nest of the ant *Iridomyrmex nitidus* at Ringwood, near Melbourne. The antennal club alone serves to distinguish it from its allied species, as the 9th and 10th joints are black, forming a striking contrast to the other pale joints. The eleventh joint is also rather strongly bent.

Westwood's specimen must have been a female (he does not state the sex), and the following well marked male characters should be associated with his description.

The metasternum is widely and rather deeply impressed down the middle, and the anterior trochanters have a minute tubercule on their outer edges, near their points of insertion with the coxae. The undersurface of the abdomen has the second segment armed with a lamelliform protuberance similar to that found in *longipilosus.* Immediately behind this there is a wide, shallow depression, which extends to the apex of the abdomen. The front tibiae are also armed with an internal tooth toward their apices.

R. strigicollis, and the three allied species here described, which might appropriately be termed the "strigicollis group," may be conveniently tabulated from characters of their uppersurface as follows.

A. Prothorax and head longitudinally strigose.
strigicephalus.

A.A. Prothorax only longitudinally strigose.

B. Antennae with two subapical joints very much darker than the rest, apical joint markedly bent.
strigicollis.

B.B. Antennae not so.

C. Clothing consisting of long, somewhat sparse, hairs.
longipilosus.

C.C. Clothing consisting of short hairs.
mirabilis.

RYBAXIS OTWAYENSIS, n.sp.

♂ Castaneous, elytra and appendages slightly paler, moderately clothed with short pale pubescence.

Head about as long as broad, lightly attenuate in front, incised at sides for the reception of eyes, inter-oculate foveae very prominent, with a shallow inter-antennal impression, and small but evenly-distributed punctures; antennae with joint 1 cylindric, viewed from above a little shorter than 2 and 3 combined, 2 subovate, narrower than 1, 3-7 more or less elongate, subequal in width, 5 longer than the adjacent joints, 8 much shorter and lightly narrower than 7, 9 a little longer and broader than 8, 10 trapezoidal, not much longer than 9, 11 equal in length to 9 and 10 combined, curved, acuminate. Prothorax lightly transverse, convex, sides broadly rounded to their widest part just before middle, thence lightly rounded to base, base a little rounded, transversal groove joining lateral foveae pronounced, more angulate hindwards than usual; puncturation rather strong and evenly distributed. Elytra transverse, apical margin of each elytron produced in middle; dorsal striae strongly defined, passing apical fourth, their apices deflected outwards; puncturation a little less distinct than on prothorax. Abdomen rather long, a little narrower than elytra at their widest, segments strongly margined, no medio-basal carinules. Metasternum broadly depressed down middle, with two small, round, fascicle filled foveae immediately behind intermediate coxae. Anterior trochanters with a minute tooth near base in front, intermediate with a prominent curved tooth at base behind. Undersurface of abdomen

with a wide, somewhat shallow excavation common to the second, third and fourth segments, fourth segment with a median subapical lamelliform protuberace directed obliquely backwards, broader at base than apex, which is somewhat truncated; apical segment lightly transversely impressed at base. Legs with femora robust; anterior tibiae robust, lightly arcuate, toothed internally just in front of middle; intermediate tibiae with a similar, somewhat more pronounced tooth just before middle, posterior much longer, thin, and lightly curved.

Length, 2.5 mm., approx. (my specimen is bent somewhat).

Habitat.—Victoria: Lorne, in moss. (F. E. Wilson).

Type unique, in author's collection.

RYBAXIS SIMILIS, n.sp.

♂ Very close to *otwayensis*, but differs in having an additional small sub-median tooth on its anterior trochanters, and in the very different structure of its second ventral segment. This, at its apex, is straight across the middle half, but on either side of the straight portion it is produced in the form of a thin plate continuing the same plane as the rest of the segment. Apparently the plate is continuous right round the dorsal surface. Being somewhat transparent ventrally it is possible to discern the normal margin of the segment beneath it. The basal abdominal excavation is also a little more pronounced than in the preceding species.

Length, 2.5 mm.

Habitat.—Victoria: Lorne, in moss. (F. E. Wilson).

This species can only be distinguished from *otwayensis* by the characters of its undersurface. In fact, I had the two specimens mounted on the same card as being identical.

Type unique, in author's collection.

RYBAXIS CRASSIPES, Lea.

Proc. Linn. Soc. N.S.W., 1910, p. 735.

I have recently taken a specimen of what almost certainly appears to be this species, from tussocks of snow grass growing on the summit of Mount Donna-Buang, Victoria. Mr. Lea's specimen was taken at Zeehan, Tasmania.

COLLACEROTHORAX SPINICOLLIS, n.sp.

♂ Dark reddish-castaneous; legs, palpi and apical joints of antennae a little paler; uppersurface generally clothed with long black hairs, but on the head and prothorax particularly; there is also a shorter pale pubescence, this most noticeable along the median lines, and in the prothoracic excavations; undersurface with pale decumbent pubescence.

Head a little elongate, with well-marked antennal tubercules, immediately behind which it is strongly constricted; deeply excavated along median line, excavation bordered on either side by a prominent

ridge terminating posteriorly in an acute tooth directed obliquely backwards, between the ridges and the eyes there is on either side a rather deep longitudinal excavation, rounded in front and bordered posteriorly by another shorter tooth directed obliquely backwards, both median and lateral excavations filled with pale pubescence; with numerous moderately defined punctures; antennae of moderate length, club of three joints, apical joint pointed. Prothorax broader than head, sides much widened on their apical halves and recurved into the form of a strong spine which is itself toothed, and which is directed upwards, a little outwards and a little backwards. On either side of prothorax is a wide, deep excavation, which forms a rather sharp edge with the uppersurface, thus making the whole discal area look like a raised shield; with puncturation as on head. Elytra a little transverse, sutural striae deep, dorsal well marked to about apical third; puncturation irregular, and not very distinct. Abdomen at widest wider than elytra, second and third segments with a very short black carina on either side, placed nearer the outer margin than the centre. Legs unarmed.

Length, 2.5 mm.

Habitat.—Victoria: Ringwood, Beaconsfield, Healesville, (F. E. Wilson).

Type in author's collection.

This insect is undoubtedly congeneric with *C. sculpticeps*, Lea[2], although its second abdominal segment is not tricarinate. The armed prothorax and different abdominal carination readily distinguishes it from that species. The antennal club differs greatly from Mr. Lea's species, the ninth and tenth joints being much less markedly transverse, and the eleventh joint being pointed instead of widely rounded. Owing to the rather dense pubescence it is somewhat difficult to see the sculpture of the head and prothorax. All my specimens were taken in damp moss growing on the ground.

SCHISTODACTYLUS ARMIPECTUS, n.sp.

♂ Castaneous, elytra and appendages paler; antennal joints 7-10 inclusive strongly infuscated; somewhat sparsely clothed with pale decumbent pubescence.

Head about as long as broad, lightly impressed between antennae, with two somewhat indistinct inter-ocular foveae; with dense, very clearly defined, punctures, becoming more sparse on disc near base; antennae with joint 1 cylindric, longer than 2 and 3 combined, 2 broader and scarcely perceptibly longer than 3, 4, 5, 6 and 7 decreasing in length, 8 wider and a little shorter than 7, 9 much wider than 8 and slightly longer, 10 wider and shorter than 9, 11 subovate, longer than 9 and 10 combined, and forming with them a three jointed club. Prothorax about as long as wide, widest at about apical third, sides strongly rounded to their widest part, thence almost straight to base which is subequal in width to apex; puncturation as on head. Elytra

2. Proc. Linn. Soc. N.S.W., 1911, Vol. xxxvi., pp. 451, Pl. xvii., f. 2, 3, 4.

short, rounded at shoulders, strongly dilated to apex; dorsal striae traceable to about apical third, both sutural and dorsal striae arising from minute foveae; with puncturation about same size but not quite so distinct as on prothorax. Abdomen about twice as long as elytra, widest at apex of second segment, on either side of which there is a rather deep fovea. Metasternum impressed in middle; with scattered punctures. Prosternum with a small conical tubercle on either side, these surmounted with a long sharp seta. Anterior trochanters about middle, and anterior femora near base, armed with a long, thin spine, the femoral ones being slightly longer. All tibiae rather strongly curved near apex. Tarsi with third joint slightly longer than the second, and armed with two unequal, widely diverging claws. Undersurface of abdomen slightly flattened along centre, with a shallow transverse fovea on sub-apical segment, this segment rather strongly produced in centre.

Length, 1.75-2 mm.

Habitat.—Victoria: Mt. Donna Buang, Belgrave, (F. E. Wilson).

This description will be found almost identical with that of *brevipennis*, Lea[3], but the fact remains that it agrees in practically every character with that species except that it has the additional armature on the prosternum. This, however, is very distinct, and is constant in all my examples. Its palpi are as in *brevipennis*, but the two spines on the sub-basal joint are about equal in length. The spine at the apex of the ultimate joint is much longer than its accompanying seta, and near the apex there are also a few very much finer setae or hairs.

Two specimens that are almost certainly females, are a little larger and have the undersurface of the abdomen much more convex, particularly on the basal segments. My examples from Mt. Donna Buang were secured from tussocks of snow grass growing on the summit, and a single example from Belgrave was sieved from moss.

Type in author's collection.

SCHISTODACTYLUS FOVEIVENTRIS, n.sp.

♂ Differs from *armipectus* in having the antennal joints 1-10 almost concolourus, and 11 very little lighter than 10; in its vestiture being a little sparser, its head more punctured on disc near base, in its less pronounced inter-ocular foveae, and in the very different undersurface of its abdomen. The first segment is very convex and declivous at apex, the third very narrow and constricted in the middle. It overhangs the base of a large cavernous fovea which extends to the apex of abdomen. The sub-apical segment only appears as a triangle on either side of the fovea. Apex of abdomen sharply produced. The transverse rows of punctures on the ventral segments are much stronger also than in *armipectus*. Apical joint of maxillary palpus furnished at apex with a spine not accompanied by a strong seta.

3. Proc. Linn. Soc. N.S.W., Vol. xxxv., (4), p. 771, Pl. xxi., f. 10.

Length, 2 mm.

Habitat.—New South Wales: Blue Mountains, (Dr. E. W. Ferguson).

In the Proc. Linn. Soc. N.S.W., Vol. xxxvi., (3), p. 455, Mr. A. M Lea records Blue Mountains, N.S.W., as a new locality for *Schistodactylus brevipennis*, Lea, on the strength of a specimen in Dr. Ferguson's collection. This specimen is the one upon which I have founded the above description. It was gummed right side up upon a card so that none of its undersurface or palpi were visible. As the uppersurface is almost identical with that *brevipennis* it is easy to see how Mr. Lea mistook it for that species. The discovery of *armipectus* so markedly resembling *brevipennis* in the characters of its uppersurface, led me to wonder if this specimen might also have an armed prosternum. On floating it off and cleaning it, I found that it was still another new species. It will thus be seen that for positive identification of a *Schistodactylus* it is absolutely essential to examine the characters of the undersurface.

For this interesting species together with many other fine *Pselaphids*, I am indebted to the generosity of my friend, Dr. E. W. Ferguson.

Type in author's collection.

The genus now comprises four species, viz., *phantasma*, Raff., from Western Australia, *brevipennis*, Lea, from Tasmania, *armipectus*, n.sp., from Victoria, and *foveiventris*, n.sp., from New South Wales. These may be tabulated as follow:—

A. Apical joint of palpi simple at extremity. *phantasma*, Raff.

A.A. Apical joint of palpi not simple at extremity.

- B. Apical joint of palpi with a spine and a strong seta at extremity.
  - C. Prosternum unarmed. *brevipennis*, Lea.
  - C.C. Prosternum armed. *armipectus*, n.sp.
- B.B. Apical joint of palpi with a spine, but no strong seta at extremity. *foveiventris*, n.sp.

Palimbolus armatipes, n.sp.

♂ Reddish castaneous; legs, palpi and elytra slightly paler; with somewhat sparse lightly golden pubescence, shorter and more decumbent on prothorax than elsewhere.

Head strongly convex, very slightly longer than broad, with two small round foveae, one on either side close to eye, and a discal fovea a little in advance of these; midway between discal fovea and antennal ridges with a deep transverse fovea; inter-antennal region raised; eyes moderately prominent; punctuation sparse and minute; antennae moderately long, joint 1 cylindric, viewed from side longer than 2 and 3 combined, 2 slightly longer than 3, 4 and 5 much broader, the latter being a little longer and broader than the former, both widened internally, 6, 7, 8, subequal and narrower than 5, 9 and 10 about equal in length to 5, but wider, the latter lightly wider than the

former, these together with 11 forming a three jointed club, 11 wider than 10, and nearly twice as long, subovate, bluntly pointed. Prothorax as broad as long, widest just before middle, with a strong longitudinal basal fovea and two round lateral foveae on either side, one basal and one submedian; puncturation as on head. Elytra transverse, with four basal foveae; rather strongly raised at shoulders. Metasternum with two prominent tubercules close together on disc midway between posterior and intermediate coxae, each tubercule crowned with a small bunch of hairs. Undersurface of abdomen with a wide shallow impression down middle, apex of fourth segment on either side at outer edge with a prominent lamellated ridge or tooth directed obliquely hindwards, its axis longitudinal. Intermediate and posterior trochanters bluntly toothed. Four front femora stout, hind femora each with a prominent black carina traversing slightly less than the middle half of its uppersurface, inner basal halves deeply excavated, excavation apicaly overhung by a wide thin plate. Hind tibiae strongly arcuate, each with a blunt oblique protuberance or tooth near base, this crowned with long fasciculate setae, a very prominent sharp tooth on inner edge of uppersurface at about middle, and a shorter sharp tooth on inner edge of lowersurface a little nearer base. Legs with puncturation rather stronger than elsewhere. Inner claw of anterior tarsi trifid.

Length, 2.8 mm.

♀ Differs in having joints 4 and 5 of antennae not appreciably wider than 3, abdomen not impressed beneath; no armature on legs and ventral segments.

Habitat.—Victoria: Healesville (F. E. Wilson), Belgrave (F. E. Wilson and C. Oke).

This species seems to have affinities with *mamillatus*, Lea[4], in its tuberculate metasternum, and *leana*, Raff.,[5] in the possession of a sub-basal tooth on its hind tibiae. Its very remarkable hind femora and tuberculate metasternum, however, serve easily to distinguish it from the latter species, and the armature of the hind tibiae readily separate it from the former.

It is sometimes a difficult matter on mounted specimens, however well set, to see the lower submedian tooth on the hind tibiae, although the upper one is always prominent. This latter, viewed from some directions, is seen to be somewhat lamelliform as in *victoriae*,[6] King. Also from some directions the fourth and fifth antennal joints do not appear to be anything like as wide as they actually are.

My Healesville specimens were taken from moss growing on old logs, and those from Belgrave were sieved from fallen leaf debris.

Type in author's collection.

PALIMBOLUS ROBUSTICORNIS, n.sp.

♂ Dark reddish castaneous, elytra and appendages paler; lateral margins of prothorax black or infuscated on their anterior halves;

4. Proc. Linn. Soc. N.S.W., Vol. xxxvi. (3), p. 449, Pl. xvii., f. 1.
5. Proc. Linn. Soc. N.S.W., Vol. xxv. (2), p. 223, Pl. x., f. 38.
6. Trans. Ent. Soc. N.S.W., 1865, p. 168, Pl. x., f. 39.

with rather dense lightly golden pubescence, this shorter on head and prothorax.

Head as long as broad, strongly impressed between antennal ridges, with two well marked inter-ocular foveae, placed well up on disc, and a faint impression on disc near base; with sparse indistinct punctures except on antennal ridges where they are very coarse; antennae of moderate length, very robust, joint 1 viewed from the side, as long as 2 and 3 combined, 2 slightly narrower than 1, almost moniliform, 3 as long as 2, widened from base to apex, 4-8 of equal width, lightly transverse, 5 a little longer than adjacent ones, 9 and 10 transverse, subequal, much wider than 8, 11 wider than 10 and about equal in length to the two preceding combined, subovate, lightly hollowed out on undersurface at base; all joints very coarsely punctured. Prothorax lightly transverse, rather more widened than usual on its apical half, with a strong medio-basal fovea, and two round lateral foveae on each side, one basal and one submedian; puncturation as on head. Elytra strongly transverse, sides increasing in width to near apex, with well marked sutural striae, and a short but wide basal impression on either side, midway between suture and lateral border; puncturation as on prothorax. Abdomen rather long, wider than elytra. Metasternum much raised in front, with two small, somewhat transverse tubercules near together in disc, immediately behind intermediate coxae; between these and posterior coxae the surface is strongly declivous, and somewhat excavated. Hind trochanters very feebly armed. Undersurface of abdomen strongly flattened, lightly excavate near apex. Hind tibiae gradually inflated internally to about the middle, thence becoming rather suddenly reduced in width, from some angles the internal inflation seems to take the form of a carina.

Length, 3.3 mm.

♀ Similar, but with hind tibiae normal and abdomen convex beneath.

Habitat.—Victoria: Warburton, in tussocks (F. E. Wilson), Belgrave, in moss (C. Oke and F. E. Wilson).

Type in author's collection.

Palimbolus pacifica, n.sp.

♂ Rather slender, flavous; antennae and abdomen slightly darker; head and prothorax sparsely clothed with moderately long pale pubescence, that on elytra longer and a little darker, appearing almost black in some lights; abdomen densely pubescent.

Head as wide as long, inter-antennal ridges rather broad, and coarsely punctate, with a deep impression between them; inter-ocular foveae strongly defined, placed well up on disc; puncturation sparse, larger on base and sides, smaller on disc; antennae of moderate length, joint 1 subcylindric, viewed from the side, larger than 2 and 3 combined, 2-6, subequal; subquadrate, lightly narrower than 1, 7 and 8 about as long as 6 but slightly increasing in width, 9 about one and a-half times larger than 8, dilated towards apex, 10 of

similar shape as 9, but a little wider and noticeably shorter, 11 narrower at base than 10, lightly curved, obtusely pointed and a little shorter than 9 and 10 combined, all joints with numerous punctures, those on basal ones being the larger. Prothorax transverse, sides widest about middle, medio-basal impression strong, lateral foveae three in number on each side, one near base, one near apex, and one submedian; punctures fairly numerous, evenly distributed, similar to those on disc of head. Elytra strongly convex, transverse, evenly rounded at shoulders, then gradually increasing in width to near apex, with a large basal impression on either side, midway between suture and lateral border, a round fovea at base of sutural striae, and these impressions; puncturation indistinct, almost wanting on disc. Abdomen about as long as, but a little narrower than elytra, its margins pronounced, and with puncturation stronger than on elytra. Metasternum a little impressed along middle of its apical half, minutely punctured, and almost glabrous on disc of its basal half, with a small round fovea filled with hairs, immediately behind intermediate coxae. Undersurface of abdomen flattened, with a very small and indistinct impression on apical segment. Maxilliary palpi with apical joint strongly inflated inwardly on its basal two thirds, sharply pointed at apex, somewhat hollowed out beneath.

Length, 2.8 mm., breadth, 1.1 mm.

Habitat.—Victoria: Lakes Entrance, in moss, (F. E. Wilson).

This interesting species differs in two main characters from all other species of the genus, firstly in possessing no armature, and secondly in the very different structure of the apical joint of the maxilliary palpus. At first glance I was inclined to exclude it from the genus, in spite of its *Palimbolus* like facies. What decided me to include it, however, was that, like the males of all other *Palimbolus* known to me, it has the inner tarsal claws on the anterior tarsi trifid.

This character has apparently not been previously commented upon, and my attention was first called to it by Mr. A. M. Lea, who showed me a specimen of a *Palimbolus* from the late Canon Blackburn's collection, to which was attached a note stating that the front claws were trifid. Species which I know to have this character are *mirandus*, Sharp, *victoriae*, King, *leana*, Raff., *foveicornis*, Lea, and the new species here dealt with. I think that upon examination all the other species also, will be found to have trifid claws.

Type in author's collection.

PALIMBOLUS? MINOR, n.sp.

♂ Dark reddish-castaneous, palpi paler; moderately clothed with short pale pubescence.

Head very lightly transverse, rather strongly narrowed in front of eyes, raised and very convex on basal half; inter antennal elevations not very pronounced, with a very shallow impression between them; with close, but indistinct punctures much obscured by clothing; eyes placed far back, prominent; antennae with joint 1 subcylindric, about

equal to 2 and 3 combined, 2 cylindric narrower than 1 and slightly longer than 3; 3, 4, 5 subequal, 6 a little shorter than 5, 7 slightly longer than adjacent ones, 9 much wider than 8, slightly transverse, 10 a little longer and wider than 9, 11 longer than 9 and 10 combined, subovate, rather strongly pointed, the last three forming a pronounced club. Prothorax lightly elongate, very convex on disc, widest just in front of middle, with a wide medio-basal longitudinal fovea and three round lateral foveae, one each near base and apex, and one submedian, on either side; puncturation as on head. Elytra lightly transverse, sides evenly rounded to their widest part just before apex; strongly convex; sutural striae well marked; with a short basal impression on either side about midway between suture and lateral margin; with numerous minute punctures. Abdomen slightly narrower than elytra, lateral margins pronounced; with puncturation as on elytra. Metasternum with two prominent conical tubercules placed side by side on disc midway between intermediate and posterior coxae, behind tubercules with surface depressed down middle. Undersurface of abdomen a little flattened. Intermediate tibiae with a strong subapical internal tooth. Trochanters unarmed. Maxilliary palpus with the three apical joints inflated externally, apical joint bluntly pointed and with several small setae at its apex, and along its inner margin. Front tarsi with inner claw trifid, hind tibiae almost straight. Femora rather stout.

Length, 1.75 mm.

Habitat.—Victoria: Fern Tree Gully, (F. E. Wilson).

A very aberrant species with head somewhat like that of a *Rytus*, strange palpi, and armed intermediate tibiae, but nevertheless I think best left in Palimbolus. Its palpi approach more those of *pacifica* than any of the other species. Its armed intermediate tibiae should serve to easily distinguish it from all other species.

Type unique, in author's collection.

EROTYLIDAE.

THALLIS ATRICORNIS, n.sp.

Flavous tinged with red; glabrous, nitid. Head less a medio-basal spot, two very large blotches on either side of prothorax, connected at their bases by a thin line traversing the basal margin, scutellum, a large circum-scutellary area, shoulders, a broad irregular median fascia with front margin angularly depressed at suture, a large blotch on either side at about apical third, each narrowly connected with a large median blotch, which is triangular in shape on its front margin and posteriorly, gradually narrowed to the apex of elytra, black. Undersurface black, except prosternum, and apical segments of abdomen. Femora black at apex, diluted with red elsewhere; tibiae and antennae black; tarsi obscurely reddish.

Head with numerous distinct punctures in front, more sparse elsewhere; antennae of moderate length, joint 3 about one and one fourth longer than either 2 or 4, 8 a little wider than 7, 9 and

10 about twice as wide as long, 11 a little longer than broad, widely rounded at apex. Prothorax a little more than one and one fourth times broader than long, its apex truncate in middle, sides very lightly rounded, with a strong notch on each side of apical margin, lateral furrows obsolete, basal furrow moderately distinct at sides, with punctures much as on base of head, but a little more evenly distributed. Elytra wider than prothorax, parallel-sided to about apical third, with regular rows of well defined punctures, becoming somewhat obscured on apical declivity, with a few extremely minute punctures on interstices. Prosternum with numerous distinct punctures on disc, almost impunctate in front and behind; intercoxal process a little widened and broadly rounded at apex. Metasternum with a longitudinal sulcus on disc, beginning at apex and traceable a little beyond the middle, with punctures very much larger at sides than on disc. Legs of normal length; front femora with two rows of finely serrated ridges on undersurface, serrations more prominent towards apex where they take rather the form of blunt teeth.

Length, 7 mm.

Habitat.—Queensland.—Mt. Tambourine (H. L. Pottinger).

This species appears to be most closely allied to *serratipes*, Lea,[7] but amongst other things it differs from the description of that species in having no well defined lateral prothoracic furrows, by the elytral punctures not being in shallow striae, in having a double instead of a single serrated ridge on the undersurfaces of the front femora, and in having legs of normal length.

Type in author's collection.

MALACODERMIDAE.

HYPATTALUS QUEENSLANDICUS, n.sp.

♂ Head black, with muzzle flavous, antennae with joints 1-4, and apical half of 11 infuscate, the rest black; prothorax, base and apex of elytra broadly, suture very narrowly flavous, rest of elytra dark bluish black; all appendages flavous.

Head transverse, highly polished and smooth, with two faint longitudinal impressions on either side between antennae; antennae reaching about middle of elytra, joints 4-10 feebly serrate internally, joint 11 a little pointed, and about one and one quarter longer than 10; prothorax impunctate, broadest at about apical third, apex arcuate outwardly, basal angles rounded, with a rather strong marginal impression widely bordering the base, and continuing around the sides to about the middle; elytra about 2½ times longer than head and prothorax combined, convex, feebly but regularly increasing in width to its broadest portion at about apical fourth; with a strong longitudinal impression on either side at lateral margin, beginning near shoulders and becoming deepest and broadest at about position of hind coxae; with strong and fairly close punctures on dark parts becoming

7. Records of the S. Australian Museum, Vol. ii., No. 2, p. 291.

a little sparser and less apparent elsewhere. Scutellum invisible. Legs long and thin, anterior tibiae feebly, posterior very strongly, arcuate.

Length, 3.75, width 1.5 mm.

Habitat.—Queensland: Blackall Ranges, (F. E. Wilson).

Type unique, in author's collection.

In Lea's table of species, Trans. Ent. Soc. Lond., 1909 (1), p. 169, this species would come under the same heading as *alphabeticus*, Lea, but the impunctate head, and prothoracic and elytral impressions, amongst other things should serve easily to differentiate it from that species.

CERAMBYCIDAE.

Sub family PRIONINI.

ELAPTUS PILOSICOLLIS, n.sp.

♂ Uniformly light brown, nitid; apex and margins of mandibles, jugular processes, knees, and margins of tibiae and tibial spurs, black or darker; undersurface slightly paler; head, portions of mandibles, prothorax, scutellum, femora, tibiae, and all the undersurface except the ventral segments covered with a long erect golden pubescence; clothing of ventral segments a little shorter and more decumbent. Elytra apparently glabrous, but viewed from the side seen to be furnished with sparse very minute setae.

Head rather small, with a fairly well defined sulcus on disc, puncturation rather sparse on disc, much closer together on clypeus and behind eyes; eyes rather wide apart; mandibles sharply pointed, with numerous punctures on their paler portions, antennae reaching apical third of elytra, scape barely over-reaching hind margin of eye, and stouter than joint 3, joints 1 and 2 somewhat closely and coarsely punctured, almost glabrous and nitid, the rest, with the exception of a small nitid spot at the apex of the 3rd, 4th, 5th, and 6th joints, covered with a very minute puncturation, and a depressed pubescence, giving them an opaque appearance.

Prothorax 4.5 x 7 mm., convex, and depressed forward, broadest at about basal third, and lightly decreasing in width towards apex, sides lightly marginate, and evenly rounded to meet basal and apical margin, apical margin lightly advanced in centre; median sulcus almost obsolete, midway between it and the lateral borders are two obscurely defined depressions, the whole closely punctured generally, but becoming a little less frequent towards the front of disc; basal and apical margins ciliated.

Elytra at base broader than prothorax, gently decreasing in width towards apex, with five somewhat obscure costae on each elytron, the first and third being the most prominent; the whole covered with large round punctures, well defined except at extreme base. Scutellum a little transverse, and broadly rounded at apex, with fairly numerous though not well defined punctures. Prosternum, metasternum, and its episternums covered with a fine, very close puncturation, this becoming

sparser on centres of ventral segments. Front tibiae widened and furnished on their outer edges with a few very blunt teeth, directed forwards; the intermediate and hind tibiae have on their outer edges some minute spinous processes; femora and tibiae fairly strongly punctured.

Length, 25 mm.

♀ Differs from the ♂ in the following characters:—Prothorax a little broader, with sides showing a tendency towards angulation just behind the middle, and pubescence mostly confined to the sides and front margin, leaving the disc almost glabrous; antennae much shorter, barely reaching the middle of elytra, and much more slender, though the scape differs in being broader than the third joint; the puncturation of joints 3-7 inclusive is much coarser than in the ♂, and the nitid spaces at the apices of the joints are much more extensive and traceable to the 9th joint. The mandibles do not exhibit any sexual dimorphism. The front tibiae are armed with six rather sharp teeth, and the spiny processes on the other tibiae are rather more apparent; the tarsi are a little less widened than in the ♂.

Length (excluding ovipositor), 28.5 mm.

It is with some hesitation that I have placed this species under Pascoe's genus *Elaptus*, firstly, because of the armature of the front tibiae, (Pascoe says "tibiae haud dentatae,") and secondly because the prothorax differs in shape so much from all the other members of the genus.

There is a small ♂ before me measuring only 19 mm. in length in which the antennae almost attain the full length of the insect.

Habitat.—West Australia: Geraldton (J. Clark), 5 ♂♂ 1 ♀.

Types in author's collection.

Co-types 2 ♂♂ in collection of West Australian Museum, Nos. 7936, 268 (1916), 2 ♂♂ in collection of Mr. J. Clark. For my specimens of this species I am indebted to the generosity of my friend, Mr. J. Clark, of Perth.

Cnemoplites (Hermerius) intermedia, n.sp.

♂, Dark chestnut-brown, prothorax a little darker; head and prothorax sparsely clothed with short upright pale pubescence, this lacking on the smooth, glossy discal areas of prothorax; anterior tibiae strongly hirsute beneath on their outer halves, this character becoming less pronounced on the four hind tibiae; shoulders, slightly pubescent; undersurface of head and prothorax with clothing similar to that upon their dorsal surfaces; metasternum and its episternums densely clothed with a very much shorter, and somewhat decumbent golden pubescence, this almost wanting on disc, but possibly due to abrasion; the brushes of the ventral segments are very dense and golden in colour, and semi-lunar in shape on the first four arches; on the last segment the hairs are shorter, and occupy a fairly large zone around the vent.

Head, moderate, disc coarsely punctured, punctures tending towards confluency; mandibles strong, coarsely punctured on their lateral declivities; antennae reaching apical third of elytra, joint 1 over-reaching apical margin of prothorax, a little longer than 3, 3 one and one-half times longer than 4; on joint 1 the puncturation is fairly close and strong, but on the other joints they become increasingly more fine and sparse; internal keel of joints only traceable on the two apical joints. Prothorax about one and three-quarter times broader than long, depressed on disc, sides declivous, lateral borders generally rounded, but crenulate or bluntly toothed, and with a small slightly upturned lobe at apical angle, towards the base the teeth become somewhat longer, but this is apparently variable, as it is more noticeable on the left side than on the right; the depressed discal area is highly polished; the puncturation which covers all the surface except a spot just above the basal centre, and two large spaces on either side of the discal impression, is very coarse, becoming somewhat rugose at the sides; the anterior border is rather strongly arched inwards about the middle, and the posterior is weakly margined. Elytra rather short, convex, wider at base than prothorax, spined at sutural angles, somewhat smoothly punctured, and glossy on basal half about suture, rugose elsewhere. Scutellum bluntly pointed behind, sparsely punctured except on a longitudinal band on basal half. Front femora coarsely granulate above, granules becoming almost spinose in parts, more finely granulate beneath; intermediate and posterior femora almost smooth above, undersurface of intermediate with sparse fine granules, and of posterior with sparse punctures; front tarsi much widened; front tibiae rather broadly channelled down the centre of the uppersurface.

Length, 48 mm.

Habitat.—New South Wales: Grenfell (T. G. Sloane).

This species seems to fall between the other two forms assigned to the sub-genus *Hermerius*, viz., *impar*, Newm., and *howei*,. Thoms. I have not been able to gain access to Newman's description of *impar*, but have had to rely upon the notes given by Lameere, who examined the types at the British Museum. My species differs from *impar* in having the third antennal joint not nearly twice the length of the fourth, the internal keel of the antennal joints not rather prominent, the elytra not without spines at sutural angles, and the femora not rugose throughout. These distinctions, together with the possession of the depressed prothoracic discal area, with its nitid smooth spaces should serve to distinguish it from Newman's species.

From *howei* it differs in being larger, in having the elytra not graulate, the body not generally pubescent above, the third antennal joint not longer than the first, nor twice the length of the fourth.

Type in author's collection.

For my specimen I am indebted to the kindness of my friend, Mr. T. G. Sloane, of Young, N.S.W.

[Proc. Roy. Soc. Victoria, 35 (N.S.), Pt. II., 1923.]

Art. XII.—*The Relationship between Dacite and Granodiorite in Victoria.*

BY H. S. SUMMERS, D.Sc.

Associate Professor of Geology, University of Melbourne.

(With one text figure.)

[Read 10th August, 1922.]

The association and field relations of dacite and granodiorite[1] at Macedon, Mt. Dandenong, Warburton and Healesville, together with the somewhat related occurrences in the Cerberean Ranges, the Strathbogie Ranges, and the Tolmie Highlands, furnish interesting material for students in petrogenesis, and in the mechanics of igneous intrusion.

In all cases the evidence proves that there was an extrusion of lava, followed by the intrusion of granodiorite or adamellite in such a manner that in every area the plutonic and volcanic rocks are brought into contact with one another. As a result of this relationship the dacite, etc., show the effects of contact metamorphism.

The Macedon occurrence is the best known, and may be taken as more or less typical of the relations that exist in the areas named.

The general field relations of the rocks in this area are shown in the map and section (fig. 1). It will be seen that the dacite is shown resting on the granodiorite over a considerable area. As the dacite has been proved to be the older rock, it follows that it must have been piled up on a platform of Ordovician sediments, and that the present justaposition of the dacite and granodiorite has been brought about subsequently.

The relationship of the batholith of granodiorite to the overlying dacite does not seem explainable by Suess's[2] conception that a batholith occupies a space formed during the dislocation of the lithosphere.

Iddings'[3] modification of this idea, viz., "that as the lithosphere in places tended to part, molten magma might enter the fracture and because of its density and hydrostatic pressure might permit the fractured parts to separate, the magma supporting its share of the overlying load," also finds little support in the occurrence under discussion. Iddings considers that the tendency to part is the result of fracturing by thrusting and flexure. It is difficult to picture any

1. Richards, H.C., Proc. Roy. Soc. Vic., Vol. 21 (n.s.), p. 528, 1908.
   Skeats, E. W., Q.J.G.S., Vol. 66, p. 450, 1910.
   Skeats, E. W., and Summers, H. S., Geol. Surv. of Vic., Bull. 24, 1912.
   Summers, H. S., Proc. Roy. Soc. Vic., Vol. 26, (n.s.), p. 256, 1914.
   Morris, M., Proc. Roy. Soc, Vic., Vol. 26 (n.s.), p. 331, 1914.
   Junner, N. R., Proc. Roy. Soc. Vic., Vol. 27, (n.s.), p. 261, 1915.
2. Suess. E., The Face of the Earth, Vol. 1, page 163, 1904.
3. Iddings, J. P., The Problem of Volcanism, p. 197, 1914.

such fracturing occurring between a dome-shaped mass of volcanic rock, and the platform on which it rests.

Turning to the hypothesis of overhead or magmatic stoping[4] it is found that this hypothesis is capable of giving a reasonable explanation of the occurrences under discussion.

The original magma before the extrusion of the volcanic phase, by means of overhead stoping reached sufficiently near the surface for partial collapse of the batholithic roof to take place, or alternately for the production of fissures connecting the batholithic chamber with the surface. In either case escape to the surface of the upper portion of the magma could take place.

In the Macedon area there is no evidence of the occurrence of any pyroclastic material so that the extrusion was not accompanied by any explosive action. The lava must have been fairly viscous, as the dacite was piled up in a dome-shaped mass, and wide spread lava flows are not found. A small flow occurs forming a tongue to the south west of Upper Macedon. At Healesville, and near Lilydale, in the Mt. Dandenong area, pyroclastic material has been recorded, indicating that conditions were somewhat different in those areas. Dome-shaped masses of dacite are also found in the Dandenong and Healesville areas.

Solidification of the dacite sealed up the vents from the batholithic chamber, and conditions became favourable for the resumption of stoping, with the result that the palaeozoic platform was entirely removed from a considerable area, bringing the granodiorite in direct contact with the dacite If this explanation be correct then we might expect to find in some area portion of the old platform which had not been entirely removed, and which should occur between the dacite and granodiorite. So far no such occurrence has been recorded, but may exist, and further field work along the contacts should be done.

The dacites and granodiorites are closely related chemically, but exhibit distinct mineralogical differences. Near Braemar House (now called Clyde) in the Macedon district, both these rocks occur, and analyses are given in the following table. A complete list of the analyses is not necessary as all have been recorded, together with variation diagrams, in the publications quoted on the first page of this paper.

The typical dacite of Macedon consist of phenocrysts of labradorite and hypersthene with smaller and less numerous phenocrysts of ilmenite and biotite set in a granulitic groundmass, consisting of quartz, orthoclase, plagioclase, biotite and ilmenite.

The phenocrysts of labradorite and hypersthene generally show corrosion, but this is more marked in the pyroxene than in the felspar. Biotite frequently occurs in aggregates bordering the hypersthene. The granodiorites consist of quartz, labradorite, orthoclase, and biotite, the ratio of plagioclase to orthoclase being nearly 6 to 1. The prin-

4. Daly, R. A., Am. Jour. of Sc., Vol. 15, p. 269, 1903.
Igneous Rocks and their origin, 1914.

cipal mineralogical difference is the presence of the hypersthene in the dacite, and its absence in the granodiorite.

In most cases the groundmass of the dacites is holocrystalline, but in two places, viz., at Cheniston, near Upper Macedon, and at Hesket,

	I.	II.
SiO_2	62·54	64·04
Al_2O_3	16·66	15·58
Fe_2O_3	1·04	0·80
FeO	5·54	4·47
MgO	2·68	2·64
CaO	3·92	3·52
Na_2O	2·66	2·42
K_2O	2·47	2·80
H_2O+	0·46	2·25
H_2O-	0·17	0·38
CO_2	nil	nil
TiO_2	1·20	0·80
P_2O_5	0·20	0·18
MnO	tr.	tr.
Li_2O	tr.	tr.
Cl.	tr.	tr.
	99·54	99·88

I. Dacite 50 yards south of Braemar House (Clyde) Stables.
II. Granodiorite, near Braemar House (Clyde).

are types with fine grained groundmass, consisting of devitrified glass. These types occur near the outer margin of the base of the dacite dome, and are practically in contact with the Ordovician sediments, and so may be taken to represent portion of the original chilled margin. Sections of these two rocks show the presence of the ordinary phenocrysts, so that it seems certain that the phenocrysts had developed prior to extrusion. With the exception of biotite, the phenocrysts are of the high temperature dry fusion type. In the normal dacite the biotite occurs most commonly as aggregates bordering the hypersthene crystals. Near the contact between the dacite and granodiorite the first sign of contact metamorphism is the production of more mica at the expense of the hypersthene, until near the junction of the two rocks the hypersthene is seen to be completely replaced by a mixture of biotite and quartz. The biotite has been formed by reaction between hypersthene and the alkali felspar molecules in the groundmass.

The Hesket and Cheniston types are practically free from biotite so that it may be inferred that the temperature of the magma at the time of extrusion was rather higher than the reaction temperature between hypersthene and alkali felspar, but that in part the cooling after extrusion was sufficiently slow for some reaction to take place.

In the Strathbogie Ranges, and the Tolmie Highlands, the effusive type is better described as quartz porphyrite, being rather more acid and distinctly coarser in grain than the typical dacite. The groundmass has the same granulitic texture, and the phenocrysts are labra-

dorite and biotite with rather rare examples of corroded hypersthene. This suggests that differentiation had proceeded rather further, and that the temperature at which crystallisation ceased had been sufficiently low for the reaction between the hypersthene and felspar to be almost complete.

Dr. N. L. Bowen's[5] theory of differentiation by sinking of crystals provides the most reasonable explanation of the relationship of the dacites to the granodiorites.

It has been shown that in the Macedon area, at the time of the extrusion of the dacite, labradorite and hypersthene had crystallised out, and that the still molten material containing alkali felspar molecules was commencing to react with the hypersthene to form biotite. The magma at this time would contain a certain proportion of water and other volatile ingredients, and some of these gases would escape when the lava reached the surface. This loss of water, etc., and the expansion of the lava due to loss of pressure, would serve to convert a magma sufficiently fluid to be able to slope its way upwards into a moderately viscous lava, incapable of extensive flow from the vent. Solidification at the border under these conditions would be rapid, and no further reaction between the hypersthene and felspar molecules would take place. Away from the margin a higher proportion of biotite would be formed, owing to slower cooling, and the lower temperature of final consolidation due to less loss of volatile constituents.

The solidification of the lava would seal up the batholithic chamber, and crystallisation of the remaining magma would continue at gradually decreasing temperatures.

Bowen believes that differentiation is mainly due to the sinking of crystals, so that the magma shows increasing acidity upwards. In the cases under consideration the upper, more acid portion, found its way to the surface, and the upper portion of the material left in the magma reservoir would be less acid than that which had reached the surface. Further crystallisation and sinking of crystals could go on, and this new upper layer would constantly gain in acidity. According to the length of time between the extrusion and the final solidification of the magma in the reservoir, so would the relative silica percentage of the volcanic and plutonic phases vary.

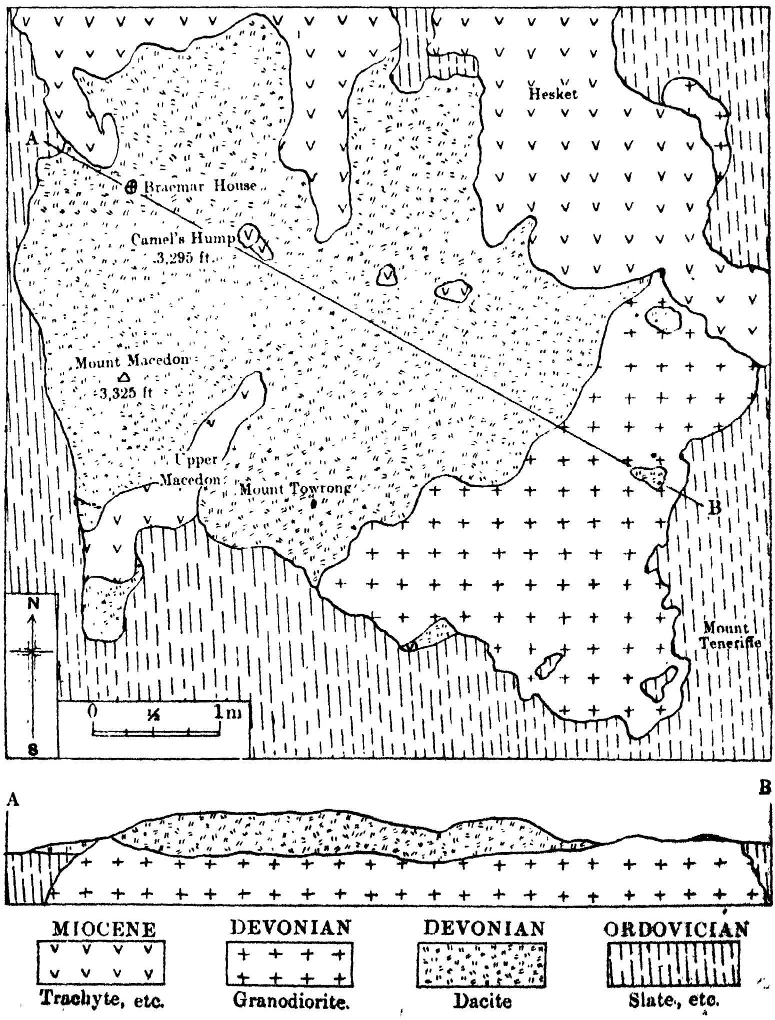
At Macedon the plutonic rock is the more acid, so that the assumption is made that there was a considerable period, relatively between the extrusion of the dacite and the final solidification of the granodiorite.

At the Strathbogie Range only two analyses have been made, one of quartz porphyrite from near Violet Town, and the other of the plutonic type from near Trawool. The plutonic type has the lower silica percentage. The temperature of the volcanic phase at Strathbogie, at the time of extrusion, was lower than that of the Macedon dacite, and differentiation was further advanced. This is shown by the almost complete replacement of hypersthene by biotite, and the greater acidity of the Strathbogie rock.

5. Bowen, W. L., Jour. of Geology, Vol. 23, No. 8, Supplement, 1915, and later papers.

After the extrusion the remaining magma would continue crystallising, but with a lower initial temperature than was the case in the Macedon area. Complete solidification would take place in a shorter period (other conditions being equal), so that the sinking of crystals ceased while the silica percentage of the plutonic type was below that of the extended rock.

The Mount Dandenong and Healesville areas are more complex as toscanites and rhyolites are associated with the normal dacites. No reliable analyses of the plutonic types in these areas have been published. Mr. M. Morris has been working out the relations in these areas, but has so far not published the results of his work, so that they cannot be discussed at present.



[Proc. Roy. Soc. Victoria, 35 (N.S.), Pt. II, 1923].

Art. XIII.—*Cylindrico-Conical and Cornute Stones.*

By GEORGE HORNE, M.D.

[Read 14th September, 1922].

About three hundred of these stones, which have been dealt with by various authors, exist in our Museums in Australia, and probably as many more may be found in private collections. They are roughly circular in section and taper to a blunt point, while the base is often cupped. Some are oval in section, and these are shorter in length, and are curved to one side, comprising the cornute type. The total length varies from three inches to thirty.

The districts in which they are found are well defined, comprising the country drained by the Darling on the East over to Lake Eyre on the West. This includes all the land of the Itchumundi, Karamundi and Barkinji, as described by Howitt,[1] over to the territory of the Lake Eyre tribes, which include the Yaurorka, Ngameni, Wonkonguru and Dieri tribes.

These stones are very variable in their composition. Some appear to have been shaped out of a mass of clay or kopi, as the gypsum is called, others are chipped out of slate or sandstone, but they may be laboriously worked out of felspar or quartzite.

As a rule the surface is smooth but in some distinct markings may be found. These may be divided into classes:—

1. The tally marks, as the short transverse markings have been named. They may be in groups of two or three up to great numbers, or they may be scattered all over the stone.
2. Longitudinal marks. These sometimes are made haphazard over the stone, or may be made singly or in pairs across the shorter tally marks, as if crossing them out or grouping them together.
3. So-called emu feet or broad arrow markings. These are in any direction and may be well cut or simply scratches.
4. Rings round the pointed end of the stones. These are not commonly found.
5 Indiscriminate markings would include the rare radiating grooves cut at the base of the stone, dints where the stone has been used as a hammer, and similar traces.

There have been at least five uses propounded for these stones:—

1. Pounders. This has been the use to which many of them have been put. When one considers the habits of the aborigines one can quite see how any hard broken fragment would be picked up for a hammer.
2. Tooth avulsion.

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1. Howitt. "Native Tribes of South East Australia."

3. It is said that they were used in the ceremonies for producing a better supply of food.
4. To mark the graves. This is undoubtedly true, but the same might be said of any other conspicuous stone, or of oval balls of *kopi*.
5. It has also been asserted that they are stuck into the ground with the base upwards, and that blood is dropped into the cupped base. I can, however, find no absolute proof that this is done. Etheridge, who has very thoroughly investigated their use, suggests they had a phallic significance.

Dr. Howitt, in his great treatise on the natives, never mentions these stones. Sir Baldwin Spencer, in dealing with them, says, "The evidence in all cases is very meagre, and inconclusive." The early settlers say, to quote Dr. Pulleine,[2] "The natives took no notice of them, neither using them, nor avoiding them in any way, and had no name for them."

Quoting Dr. Pulleine again, he says, "Mr. John Conrick, of Nappa merri, Cooper's Creek . . . . tells me that, although he has lived there since the early seventies, he has never seen them used, or noticed by natives, and that they are known there simply by the name of Moora."

From my own observations, and from those of Mr. Aiston, who is elder brother to the Wonkonguru people, East of Lake Eyre, we found them recognised by the old aborigines, but not at all by the younger men.

The old men would be from seventy to ninety years old. Their age is calculated by their status when McKinley first came to the district, and by their relative ages. Thus—"me boy, this one man"—when told by a seventy years old man makes the second one eighty. This old man when shown the stones, said "Kootchi, Kootchi, Moora," meaning that they were uncanny and belonged to the Moora.

A most interesting stone is the *Karamoola Yudika*, or circumcision stone. Mr. Aiston has one of these which is slightly broken at the lower end, but is not hollowed at the base. He also sent two to Melbourne. One of them is in two pieces, the other whole. They were all found on the sandhills near Kalamurinna. I showed this one that Mr. Aiston has to my old native friends "Koonkoo Nutaculli," and "Tarkarawikari." They each at once averted their eyes and with palms of hands raised and turned outwards, motioned me away with it saying, "Kootchi, Kootchi" (uncanny, uncanny). They stated "Moora use make'em man," but to Mr. Aiston they have each told the following story. He says:—

"They are supposed to be the *wonto* or penis turned to stone, of someone who died as the result of having been circumcised with a firestick. When the Moora's showed how the operation should be performed with a knife, they brought one each of these stones along. The foreskin was stretched over the point of the stone, which was held opposite to, and in prolongation of, the penis. The stone knife then cut around the end of the stone. After the operation was all

2. Pulleine, Trans. Roy. Soc., S. Aust. Vol. XLVI,, 1922,

over, the old man who did the cutting put the *karamoola yudika* under his arm and went away. He was supposed to lose it without knowing where it was dropped. I imagine that his arm tired, and he dropped it without particularly noticing where. If afterwards it was found, the finder covered it up and the place where it lay was carefully noted, so that when wanted again, it could be recovered. These stones were supposed never to be made by man.

"Later it was found that the operation could be performed without the use of the stone, so a small cylinder was employed. This was just held in front of the penis and in prolongation of it. Directly the foreskin was off the stone was dropped on the sand. This substitute was then lost in the same manner as the original. My informant was at great pains to convince me that the aborigines did not make them. The Moora made them, in the same way as he made fossil wood into stone. This old fellow," concludes Mr. Aiston, "nearly fainted when I showed him the *karamoola yudika*. He was horror-struck for the minute, and then told me the above."

At present even the short substitute stone is not used, but a piece of wood, conical in shape, and made like a spear point, is employed.

After the ceremony this is shown to the boy and its significance is explained.

One of the men from Cowarie on the Diamantina had left behind him, at a deserted camp, a box obtained from the homestead containing three *coorie toorooka*, or the mussel shells given to the initiate, a store of *munyeroo* seed, and, wrapt up in a bit of rag, a conical spear point stick. It was plastered thick with red ochre and fat, and it smelt. Evidently these were prepared for the ceremony which is to take place, when the Government bonus for wild dog pups is finished, and the tribe can gather again.

This report has some weak points. The cylindrico-conical stones are found most commonly in the valley of the Darling, and its tributaries.

Here, however, circumcision is unknown, and records of the uses above related are only to be found amongst those who still practise the rite.

There are, to account for this, stories of changes of place amongst various tribes. Thus the Wonkonguru say that they formerly lived north of the Diamantina, but were driven south by the Ngameni. They in their turn displaced the Dieri who now live south of Cooper's Creek.

Something similar may have been the lot of the Itchumundi, Karamundi and Barkinji, who pushed eastward from the Grey and the Barrier Ranges. On the other side of these mountains circumcision is still practised.

Both in weapons and in language there is a remarkable resemblance between those dwelling to the east and those to the west of these mountain ranges.

Take for instance the following list of works quoted from E. M. Curr, Australian Race, Vol. II., p. 168.

English.	Darling Language.	Lake Eyre Languages.	Locality.
mother	- Ngamukka	Namika	- Mt. Serle
water	- Ngookoo	Nguka	- Cooper's Creek
rain	- Mukkra	Mukkra	- Mt. Remarkable
kangaroo	- Thurlda	Thuldra	- Cooper's Creek, etc.
opossum	- Bilta	Pilta	- Widely spread
native companion	- Kooroolko	Booralko	- Cooper's Creek, etc.
one	- Nitcha	Ninta	- Macumba R.
mosquito	- Koondee	Koontee	- Cooper's Creek, etc.
ear	- Uri	Uri	- common
mouth	- Yalla	Yalla	- Umbertana
fire	- Kulla	Kalla	- Marachovie
boomerang	- Wana	Wanna	- Beltana
night	- Tunka	Tinka	- Cooper's Creek

Then again on both sides of the ranges we find that there are two exogamous intermarrying classes with female descent.[3]

These are bounded on the east and north by tribes with four classes; and on the west and north by those with four intermarrying groups and descent in the paternal line.[4]

The only thing that can be suggested is that a series of dry seasons, or some plague, drove away all the natives from the Darling Valley, from which they fled, leaving the cylindrico-conical stones. There is a tradition, quoted by Commissioner Lochardt,[5] that a second migration took place long ago, when one man with his two wives, Kilpara and Mukwara, occupied the empty country. These two wives gave class names to the Darling tribes,[6] and, judging by the language resemblances, their arrival could have been at no great date. That circumcision would not be practised amongst these immigrants would, as Curr suggests, be obvious, because the small party could not afford to lose any of its members and food for all was assured.

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Art. XIV.—*The Increasing Run-off from the Avoca River Basin (due apparently to Deforestation).*

By E. T. QUAYLE, B.A.

(With one Text fig.)

[Read 9th November, 1922]

Some consideration has been given to this in a previous paper dealing with the Control of Climate by Human Agency. This, however, was very casual and depended mainly upon the writer's impressions, which are based upon recollections going as far back as 1870.

The chief points of interest are:--

1. The flooding of the river,
2. The duration of the flow each year,
3. The minimum flow each month,
4. The actual run-off.

These are obviously influenced by the changes wrought through our occupation of the drainage areas of the river, which dates back only for about 60 years. Such pastoral use as had been made of it for a few years previously was probably negligible in its effects.

Physiographic Changes.

The recent changes in the stream beds, which appear to have begun about 1880, have been most striking. Up till about that time large waterholes, many of which were 20 to 40 yards long, 10 to 15 yards wide, and 8 to 10 feet deep, were a feature of the streams, and occurred at very short intervals, usually of only a chain or two. The channels connecting these were almost always very shallow. One old resident of Amphitheatre, a lady, testified that she was able, in 1861, to step across the Avoca River, or Glenlogie Creek anywhere. For the next 30 years, or until the early 'nineties, the changes in the channels of the Avoca River, above the town of Avoca, and in its tributaries generally, were not particularly noticeable, but during the last decade or two have become very marked. The destruction by stock of the reeds and coarse grasses lining the channel, and the removal of logs and growing trees, have permitted the beginning of erosion, and this has lately become rapid. The effect is a double one. The aquatic grasses which often covered the beds of the smaller streams, and the coarse grasses and trees which lined the beds being destroyed, the cutting of the channel began. This gradually lowered the level of the water in the water holes, and now in most cases has almost completely drained them. When the flow is rapid, a fairly deep and

uniform channel is eroded, but so far I have seen no serious lateral erosion. The rich, black soil flats are being deeply scored, but there has not been any great loss of area, although the deposition of masses of gravel and shingle in talus or delta fashion, where the streams emerge from the hills, or reach flatter country is damaging many rich pastures. Fords are difficult to maintain, and much bridge building is becoming necessary in order to keep up traffic. Another effect of this erosion becomes manifest wherever the streams reach flatter country. The sand resulting from this erosion, especially in granite country, is carried downwards into the waterholes, and is obliterating one after the other. So that, whether the river flow is rapid or slow, the waterholes have to disappear—either by draining or silting. From the angler's point of view, this is particularly sad, as these water holes once provided fine fishing. About Amphitheatre and Avoca, mining operations are popularly blamed for the silting, and no doubt these have had an appreciable effect, but the filling and draining of the water holes were inevitable in any case.

Clearing of the Forest Covering.

Above the junction of the Avoca, with its western tributary, the Amphitheatre or Glenlogie Creek, the area drained by the two systems is about 42 square miles, of which 23 square miles is drained by the Avoca River. Standing on the Sugarloaf, a peak about 1700 feet high between the two drainage areas, a good view of both is obtained. To the eastward lies the Avoca Valley, and to westward that of the Glenlogie Creek. The former was once the site of a large pastoral property, the Amphitheatre station. Though a true basin, and the country not very hilly, it does not seem suited for extensive cereal agriculture. There are, however, many flourishing apple orchards. It is a typical pastoral area, pleasant to look upon, and dotted over with well foliaged trees, mainly Eucalypts. These are apparently retained for shade purposes, and although unusually numerous for those, are not numerous enough to constitute forest. Most of the basin has been in its present state for perhaps 20 or 30 years, but within the last decade much clearing has been done on the slopes of Mt. Lonarch and Ben More, as well as on the Sugarloaf itself. On Mt. Lonarch the clearing is most noticeable, especially within the last five years, and amounts to perhaps two or three thousand acres.

Looking westward from the Sugarloaf over the Glenlogie Creek basin great alterations are apparent during the last five years, the forest country being now limited to a strip a mile or two in width running W.S.W., from the Amphitheatre township for about three miles along the southern side of the railway line, and it evidently will not be long before the firewood cutters will have cleared this area also. In that case the two basins will form one area practically cleared, except for the State forests, which cover the higher portions of the surrounding ranges, the Pyrenees to the north-westward, the Lonarch to the south, and Ben More to the east.

Effects upon the Permanence of the Streams.

It is common knowledge in that district that the clearing of the timber has most strikingly improved the summer flow of the streams, by increasing the activity and duration of the springs. It is within the writer's knowledge that the creek taking its rise in the granite hills south of "The Gap," the highest point on the road from Avoca to Ararat, and on the divide between the Avoca and Wimmera River basins, was, prior to 1881, dry for the greater part of each summer. Now it is a permanent stream, and even on April 19, 1922, was discharging perhaps five cubic feet per minute. The same applies to the Avoca and Glenlogie creeks at their junction below Amphitheatre, and both were running freely on the same date. It was of interest to note, too, that the two streams were there nearly equal, whereas prior to 1880 the Avoca was much the larger whether under flood or summer conditions. For this approach to equality, the cause is evidently the greater recent reduction in the forest covering of the Glenlogie Basin.

The deepening of the channels has had effects upon the extent of the flooding. According to Mr. Ennis, an Amphitheatre resident, the flats are now flooded less frequently and extensively than formerly. This is due in all probability to the increased channel capacity which also involves increased velocity. A proof of the latter was found by inspection of the Avoca branch, coarse sand and gravels generally being distributed very freely over the river flats and to an extent obviously very injurious to their pastoral usefulness. This was not the case formerly.

In response to my request, the Postmaster at Avoca submitted a number of queries to an old Avoca resident, Mr. Henry Brown, who kindly answered them very fully. His statements agreed very well with my impressions, except that he attributed the recent greater permanence of the river flow in summer to good spring rains and its occasional failures to the water carrying capacity of the underground drifts, which, if tested, he said, would show that the river never ceased flowing at all. Floods, he said, came down more rapidly than formerly, for which he blamed the silting up of the large waterholes by mining operations. Thousands of diggers had washed their dirt in the river, and the Golden Stream Gold Mining Coy. had run thousands of tons of "slum" from their puddlers into it. In places this slum in the bed of the river was 5 ft. thick. The floods were also heavier than previously, for which again he blamed the silting up by mining operations, causing lessened channel capacity. These siltings he also blamed for various changes in the course of the channel.

My observations of the changes in the country cover only a small part of the Avoca's drainage area, but it is probable that they apply with equal force to the whole area between the Avoca and the Pyrenees which provides the chief remainder of the effective drainage areas, or of a total of about 1000 square miles.

The flow of the Avoca River is officially measured by the State Rivers and Water Supply Commission at the Coonooer Weir, below

which the river gains only negligible additions. These records began in June, 1889. This weir appears to be the only interference with the flow of the Avoca River, the waters of which have never been seriously used for irrigation. The basin is, therefore, very suitable for such a study as the present one.

Summer and Minimum Flow Improving.

Inspection of the data published by the Water Commission shows a remarkable change in the constancy of the flow of the river. If we compare the records for the twenty years, 1890-1909 inclusive, with those for the ten years, 1910-1919, we find that in the former period the river actually had no flow or ceased to run in 79 months; that it, there were 79 months during the whole or a part of which there was no discharge at Coonooer Weir, or at all events nothing more than the leakage which does not exceed one-sixth of a cubic foot per second. During the decade 1910-19, the river has never ceased to flow, nor has it done so up to the end of 1921. A comparison of the two great drought years, 1902 and 1914, is equally instructive. Though the latter was the more severe the river flow never fell below 5 cubic feet per second, whereas in 1902 there were seven months during which the river never ran at all.

The following table shows the average minimum flow in cubic feet per second for all months for the twenty years, 1890-1909, and for the ten years, 1910-1919:—

Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct	Nov	Dec.	Avg
1890–1909.												
1·4	0·65	1·0	1·2	1·8	7·3	16·1	24·7	18·1	10·7	6·0	3·0	7·6
1910-1919.												
8·3	7·5	8·7	8·6	8·6	8·8	30·8	29·3	33·5	27·2	15·3	9·1	16·3

This shows that during the summer half of the year, November-April, the average minimum is now from *two to ten times* as great as formerly, and is also considerably greater during the winter half. That this is not due to any marked increase in the frequency of flood rains is shown from the records of Amphitheatre, Avoca, Stuart Mill, Emu and St. Arnaud. Taking all the occasions when the mean of the daily rainfalls at these stations has equalled or exceeded 50 points, or for two consecutive days 75 points, we get the following:—

	Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890–1909	6	5	13	16	16	26	16	10	10	10	9	8	145
1910–1919	2	8	7	4	9	12	10	7	11	5	8	7	85

Here the total "flood falls" for the summer halves are 57 for the former and 31 for the latter, and for the winter halves 88 and 54, showing clearly enough that it is not to any special increase in the

number of heavy rains the increased minimum flow of the river is due.

The Floods on the Avoca.

To estimate with any degree of accuracy the maximum volume of flood water likely to follow upon any rainfall seems almost impossible. We should need to know not only the amount of the rain for the day, but its intensities from hour to hour, the distribution in time and place of the heaviest showers, the degree of saturation of the soil, the amount of grass covering it, as well as the state of the river. Present data will not allow of these being weighed. Some generalised results may, however, be valuable.

As before mentioned, Amphitheatre, Avoca, Stuart Mill, Emu and St. Arnaud were the stations selected by me to provide the necessary daily rainfall data. These covered the effective drainage area very well. The rains necessary for flooding were reckoned, those of 50 points or more for one day, and 75 points or over for two days' rain. In the diagram these are shown graphically in spaces allotted for each month since 1889 along with the greatest volume in cubic feet per second, passing over the weir during each month.

During the 32 years with available records, the heaviest flood was in August, 1909, with probably well over 5000 c.ft. per second. Next came that of September, 1916, which was put at 5000 c.ft. Floods of 4000 c.ft. per second or over were reached in May, and in June, 1892, in September and October, 1893, in January, 1897, in March, 1910, in September, 1912, in September 1915, and in September, 1921.

The time distribution of all floods was as follows:—

c. ft. per sec.	Jan.	Feb.	Mar	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Over 5000	—	—	—	—	—	—	—	1	1	—	—	—
4000–5000	1	—	1	—	1	1	—	1	5	1	—	—
3000–4000	—	1	—	—	2	6	3	5	11	2	2	—
2000–3000	—	—	—	1	—	6	4	3	1	—	—	—
1000–2000	—	—	—	—	1	1	7	8	3	4	2	—
	1	1	1	1	4	14	14	18	21	7	4	0

(1000 c.ft. per second would be given approximately by a stream 100 yds. wide and 1 ft. deep, flowing at a rate of 2 miles per hour.)

According to these figures floods are extremely unlikely to occur in the summer months, and they reach their maximum frequency and intensity in August and September.

The importance of the degree of soil saturation is made very obvious by the fact that the heaviest flood falls have not occurred in these months. The greatest of these was in March, 1910, when the mean for two days was 5¼ inches. The flood of January, 1897, was due to a fall of over 4 inches in one day. In February, 1911, a three-day fall gave 436 points. In April, 1890, 313 points fell on one day. In May, 1893, a fairly even five-day fall gave 5 inches. In July, 1903, 320 points fell in two days. The great flood of August, 1909, was due to a series

of thunderstorms giving a total fall of 3½ inches in about 19 hours, with its heaviest downpours during the last hour over the head streams. The great flood of September, 1916, was due to 260 points falling in two days.

For the whole 32 years, 1890-1921, the number of rainfalls with flood possibilities (over 50 points for one day or 75 for two) were as follow:—January 9, February 13, March 20, April 20, May 27, June 43, July 28, August 21, September 25, October 15, November 14, December 15. These are very different from the actual numbers of floods occurring these months, except in August and September.

Flood Volumes Increasing.

Owing mainly to the variability in the dates on which the winter rains may be said to have begun, and the soil to become well moistened, the only months which show any approach to consistency in the relation between the rainfalls and resulting floods are July, August, and September. Taking an average of all the rains with flood possibilities, we get the following results for the earlier and later periods:—

—	July.			August.			September.		
	No.	Average Rainfall	Flood in cusecs	No.	Average Rainfall	Flood in cusecs	No	Average Rainfall	Flood in cusecs
1890-1909 - - -	13	103	1444	11	116	2135	10	114	1766
1910-1921 - - -	10	93	1641	9	110	2092	11	149	3564

So far as these results go, they show an improved run-off during the later period.

Flood Rains and Flood Volumes.

As already remarked, the run-off after any particular rainfall varies enormously and can only be guessed at with any probability of success when other conditions are known. For example, it is only the very exceptional rainfall which will cause serious flooding of the river during the six summer months, November to April. November can only show three floods in 32 years, a rainfall of 194 points, giving 3600 c.ft. in 1893, a rainfall of 277 points, giving 3850 c.ft. in 1903, and a rainfall of 166 points, giving 1900 c.ft. in 1906. In December there have been no floods. In January only one, a 411 points rain in one day, in 1897, giving a flood of 4100 c.ft., in February only one, a three-day fall of 430 points giving a flood of 3850 c.ft. in 1911; in March only one, a three-day fall of 552 points, giving a flood of 4000 c.ft. in 1910; in April only one, a fall of 313 points in 1890, giving a flood of 3500 c.ft. The comparative rareity of floods in May and October is probably also due to the liability of the soil to be dry in those months. In the case of the former, because the dry season is usually scarcely over; in the case of the latter, because growing vegetation is making

great demands upon the soil moisture, as well as obstructing the flow of water down the slopes of the drainage area.

Flood Prediction.

As the months of June, July, August and September are obviously the flood months, it may be worth while giving in tabular form some average results based upon the whole 32 years' record. All Junes and Julys preceded by months with less than 2 inches of rain are excluded. The flood rains are grouped as follow:—under 1 inch, from 1 inch to 149 points, from 150 points upwards. While the variation is great for all months, that for June is particularly so.

Month.	Rainfalls under 100 points.			Rainfalls of 100 to 149 points.			Rainfalls of 150 points and over.		
	Average amount.	No	Flood volume in cusecs	Average amount.	No.	Flood volumes in cusecs.	Average amount.	No.	Flood volumes in cusecs.
June - -	76 pts.	6	600	126 pts.	6	2190	170 pts.	6	2500
July - -	80 pts.	12	1400	129 pts.	5	1870	235 pts.	2	3600
August -	83 pts.	8	1740	122 pts.	6	2340	230 pts.	3	3970
Sept. -	87 pts.	7	1460	125 pts.	7	3160	196 pts.	9	3590

Annual Run-off Increasing.

That the volume as well as constancy of the flow of the Avoca River over the Coonooer Weir is increasing greatly is shown decisively by the official gaugings. As previously remarked, so many factors powerfully affect the run-off that unless the chief of these are known it is hopeless to attempt to estimate the flood height from any particular rainfall. But by taking a sufficiently long period it may be assumed that average results will provide data for reasonably reliable deductions. The official guagings cover 32 years. These provide three decades, exclusive of the years 1920 and 1921. The first of these, 1890-1899, was the wettest, giving an average of 20·1 inches annual rainfall, and an average annual run-off of 59,278 acre feet. The next decade had an average rainfall of 19·4 inches, and a run-off of 44,230 acre feet. The last decade 1910-1919, had a rainfall of 19:5 inches, and a run-off of 74,439 acre feet. Taking a mean of the first two, we get an average run-off of 51,700 acre feet for a rainfall of 19:7 inches. As the average rainfall for the last decade was 0:2 inches less, and the average run-off 22,700 acre feet more, there seems no reason to doubt that the run-off is increasing. This is made even more emphatic by taking in the years 1920 and 1921, with rainfalls of 19 and 22 inches respectively, and run-off totals of 94,909 and 93,155 acre feet. These make for the last 12 years the average run-off 77,700 acre feet, for an average rainfall of 19:7 inches. The rainfall therefore averages out the same as for the previous 20 years, but the run-off has increased by 26,000 acre feet, or by over 50 per cent. (The rainfall data here used are those published by the Water Commission.)

The improvement in the run-off may be made more obvious perhaps if we limit the comparison periods to the winter months and begin each flood season only with those months prior to which sufficient rain has fallen to make the soil fairly moist. This will require, say, two inches of rain during the preceding month. This means that the period will rarely begin before May and will end not later than October. Adopting this procedure and using the rainfall data from the five stations selected by myself, which are slightly wetter than the average for the basin, the following results were obtained.

The years 1890 to 1909, omitting the great drought year, 1902, gave a total of 102 months with an average rainfall of 2:53 inches, and average mean monthly river flow, of 152 c.ft. per second. The years 1910 to 1921, omitting the drought years 1914 and 1919, gave 50 months, with an average rainfall of 2:75 inches, and average river flow of 270 c.ft. per second. That is, unless the run-off has improved, an increase of 22 points in the rainfall gives an increased run-off of 118 c.ft. per second, or a 10 per cent. rainfall increase means a 60 per cent. run-off increase, which seems hardly possible.

In order to get a series of earlier years with approximately the same rainfall as that of the later series, it will be necessary to reject, in addition to 1902, the rather dry years, 1895, 1896, 1897, 1899, 1904, and 1907. The remaining 13 years give an average monthly rainfall of 273 points, and an average mean river flow of 187 c.ft. per second. Therefore, for practically the same rainfall we get an increase in the run-off of nearly 45 per cent.

The very wet months in these periods, or of over 4 inches, were as follow:—

1890, June, 431 pts.
1893, May, 660; June, 485 pts.
1894. October, 605 pts.
1898, June, 520 pts.
1899, June, 456 pts.
1900, August, 403 pts.
1906, May, 448; June, 438 pts.
1903, July, 481, and Sept., 409 pts.
1909, August, 695 pts.
1911, September, 406 pts.
1912, September, 536 pts.
1915, Sept., 547; June, 419 pts.
1916, June, 410; Sept., 457 pts.
1920, August, 505 pts.
1921, September, 44 pts.

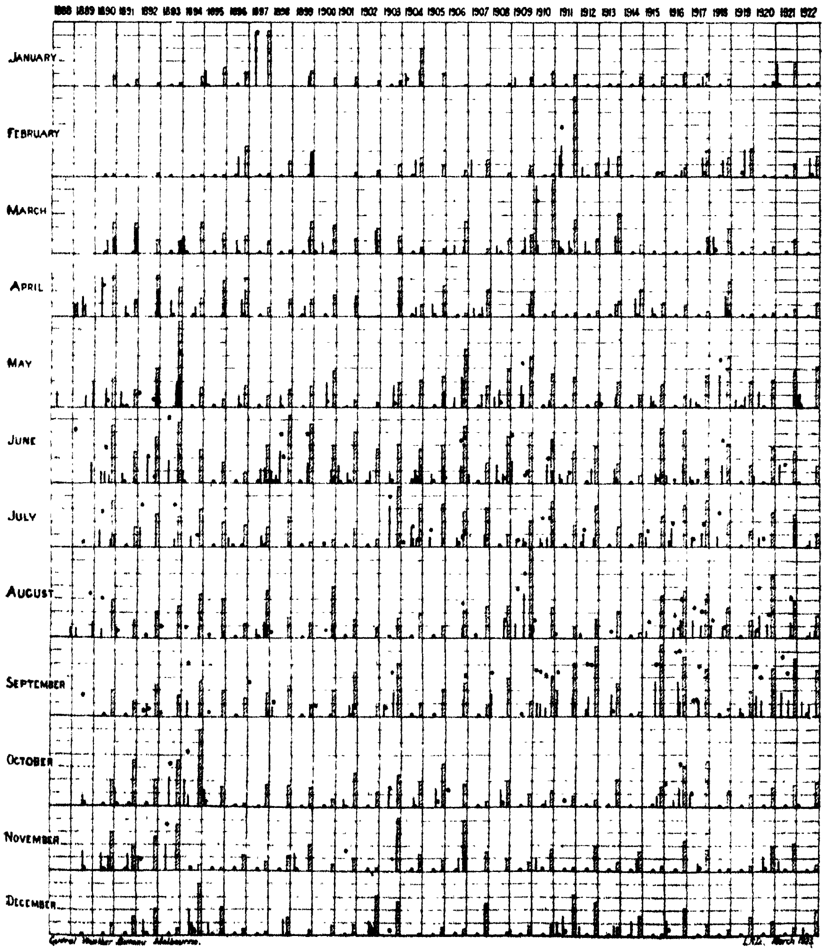
This gives 12 for the 20 earlier years, with an average of 503 pts., and 8 for the later 12-year period, averaging 466 pts.; which rather favours the earlier period as regards flood possibilities.

This 45 or 50 per cent. gain may be apportioned to the two main sources of increased flow, (a) the amount gained by springs from the destruction of the trees, and given to maintain a constant flow; (b) the increased run-off due to the better drainage resulting from erosion of channels, silting up of water holes, formation of paths by stock, moister condition of subsoil, quicker saturation of the subsoil due to killing of the trees, the raising of the water table, etc. It has already been shown that the former results in an average increased minimum flow of 8:7 c.ft. per second. This gives for one year, 6300 acre feet. That leaves, therefore, as the gain due to the second group of causes about 20,000 acre feet.

All the information available goes to show that the changes described for the Avoca River basin are common to all our inland drainages. If so, the results must be of the utmost importance. Our inland water supplies may be increased greatly, and if properly utilised may produce effects, climatic included, beneficial beyond anything we have yet ventured to anticipate.

The bearing of this upon the filling of our inland lakes, such as Torrens and Frome, and the resulting climatic improvement is obvious.

Graph showing for the Avoca River basin:. (a) the flood rains; (b) the resulting flood volumes; (c) the total rainfall for the month.



Each vertical space represents, in the case of rainfall, one inch; in the case of flood volume, 1000 cubic feet per second. The rainfalls are indicated by vertical lines and hatched columns, the flood height by the position on the vertical scale of the round dots. For (a) and (b) the dates of occurrence are indicated by their position on the horizontal scale.

[Proc. Roy. Soc. Victoria, 35 (N.S.), Pt. II., 1923.]

Art. XV.—*Additions to the Australian Ascomycetes. No. I.*

By ETHEL McLENNAN, D.Sc., and ISABEL COOKSON, B.Sc.

(With Plates IX., X., and 1 Text Figure.)

[Read 9th November, 1922.]

This paper contains an account of several new Victorian Ascomycetes. The Australian forms of this group have so far not received very much attention from botanists, and although several fungal papers have appeared, these deal mainly with the Basidiomycetes of this country. Cooke, in the introduction to his "Handbook of Australian Fungi," remarks on the small number of Discomycetes and Pyrenomycetes recorded for Australia, as compared with other countries. The authors hope from time to time to record and describe new members of these groups in a series of papers under the above heading.

I.—Sphaerosoma alveolatum, sp. nov. (Plate IX.).

Corpore fructigero cervicaliaceo, colore modo atro-fusco modo nigro, ·5-1 cm. diam. sessili. Hymenio perperidium limitato. Ascis cylindricis 40μ diam. cum iodino caeruleis. Sporis octo globularibus subfuscis, alveolatis 34-36μ diam. Paraphysibus clavatis subinde ramulatis.

Fruiting body cushion-like between fleshy and cartilaginous, dark brown to black, viscid, 0.5-1 cm. in diam., and from 1.5-2 mm. high, sessile, with a broad attaching base, hymenium limited by a peridium, internally dark, pseudoparenchymatic. Asci cylindrical, clavate, 40μ diam., and 300-400μ long, blue with iodine, operculate. Spores 8 globular, light brown, uniseriate, irregularly alveolate, 34-36μ diam., 26-28μ without the wing. Paraphyses not exceeding the ripe asci, clavate, septate, often branched.

On open clayey or sandy soil, near Castlemaine, Vic., and at Ringwood, near Melbourne, Vic. (I. Cookson). August and September, 1921.

The plants are mostly scattered, varying in size, with a broad basal attachment, and are not easily detached from the substratum. They are usually rounded in outline, occasionally slightly lobed, the convex upper surface giving to the plant a cushion-like appearance; this surface is nearly always smooth, but sometimes it is slightly convolute. Plants are dark coloured, even when young, and almost black in the adult condition; when moist they are viscid and shining. Internally they are also dark coloured; the hymenium does not cover the entire outer surface of the plant, but is bounded at its extremities

by a distinct peridium [Plate IX., figs. 2 and 3 (p)]; it is composed of large cylindrical asci and numerous paraphyses.

The asci when young contain the ascospores grouped towards the distal end of the ascus in a biseriate fashion [Plate IX., fig. 3 (s)], as they become mature the spores are arranged in a monostichous manner, they are 8 in number, globular, and alveolate in character [Plate IX., figs. 4, 7], light brown at maturity and 34-36μ in diameter. The asci turn blue with iodine, and are distinctly operculate.

The paraphyses do not extend beyond the asci to any extent in the ripe specimens; they are septate, swollen towards the apex, very often branched, the two branches being equal [Plate IX., fig. 5], when old they become brown at their apices and tend to shrivel.

The sterile portion of the receptacle is composed of large pseudoparenchymatous cells without a well marked hypothecium, the extension of this sterile tissue in the form of a peridium can be seen macroscopically, when fruiting bodies are cut in vertical section [Plate IX., fig. 2].

The genus *Sphaerosoma* was founded by Klotzsch (1) in 1893, and it has been the subject of much discussion. Uncertainty as to the exact characters of the type species *Sphaerosoma fuscescens*, Klotzsch, collected in the Grunewald, and also in the Botanical Gardens near Berlin, led to many conflicting statements, and as a consequence much confusion existed in regard to the members of the genus. In 1909, Rouppert (2) published a revision of the genus *Sphaerosoma*, and this was followed in 1910 by an exhaustive account of the genus by Setchell (3). This paper includes the principal references to the genus and its various species, so that it is unnecessary to deal with these in detail here.

As Setchell points out, Klotzsch figures his type specimen as possessing echinulate spores, but describes them as verrucose in character. Later Corda (4) and Zobel (5) figured this species with tuberculate spores. As no type specimen had been preserved, much confusion naturally arose. Setchell, after examining material of all the species be could secure, and considering all the points in this mass of conflicting ideas, states that "the weight of probability can hardly prevail against the really convincing figures and description of Klotzsch."[1] He therefore regards the echinate spore as characteristic of the type, and considers that *S. Janczewskianum*, Rouppert, is probably identical with *S. fuscescens*, Klotzsch, as the spines on the spores are short, rather than with *S. echinulatum*, as the spines on the spores of the European (Rehm and Rouppert) and American (Seaver) form of this latter species are longer and stouter.

Setchell in comparing these echinulate-spored forms with others described under the genus *Sphaerosoma*, shows that in addition to their spore marking they are characterised by the possession of a distinct peridium. In a young form of *S. echinulatum*, Seaver, the

1. The writers are cognisant of a paper "Observations on *Sphaerosoma* and allied genera," by J. F. Seaver (6), but follow Setchell (loc. cit.) in preferring to accept Klotzsch's figure as expressing the characters of the type in the absence of an authentic type specimen.

hymenium was almost completely surrounded by the peridium; for this reason he suggests that these forms do not belong to the Helvellineae, but should probably be regarded as members of the Pezizineae, and restricts the genus *Sphaerosoma* to them. The reticulate-spored forms known at this time did not agree in this respect, and Setchell considers them to belong more properly with the Helvellineae as the hymenium covers the entire outer surface,[2] and to fall into the genus *Ruhlandiella*, Hennings.

The genus *Sphaerosoma* then, according to Setchell, contained 2, or perhaps 3, species:—

1. *S. fuscescens*, Klotzsch, identical with *S. Janczewskiana*, Rouppert.
2. *S. echinulatum*, including *S. echinulatum*, Seaver, the American form, and *S. echinulatum*, Rehm and Rouppert, the European form.

These members agree in possessing a peridium and having echinulate spores. The Australian specimens (*S. alveolatum*) should undoubtedly be included in this genus, they resemble the known forms in their structure, but as they possess reticulated or alveolated spores they illustrate another species of *Sphaerosoma*. The echinate spore marking cannot therefore be regarded as a generic character, and Setchell's idea of the genus as restricted to echinate-spored forms must in consequence be enlarged.

This is the first record of the genus for Victoria. Rodway (8) has recently published a form under the name *S. tasmanica*, Rod., which, however, shows no affinities with *S. alveolatum*, McL. & C. His plant is described as "hollow, closed or opening on one side towards the base, the hymenium lining the internal surface," and, as possessing elliptic spores. These characters differ so widely from the accepted limitations of the genus as to probably exclude from it this Tasmanian form.

LAMPROSPORA AREOLATA, Seaver, var. australis, var. nov.

(Text figure I.).

Plantis 1-3 mm. diam. Hymenio aurantiaco, margine in morem institae exstanti circumdato. Ascis 20-22μ diam., cylindricis. Sporis globosis reticulatis. Areolis 2μ, altispora tota 18-20μ diam. Paraphysibus simplicibus, clavatis 4-6μ diam., granulorum aurantiacorum, refertis.

Plants gregarious but not crowded, 1-3 mm. diam., at first closed, globose, later expanding, hymenium bright orange-red plane, or slightly convex, at first smooth, later roughened by protruding asci, finally spongelike, surrounded by a raised frill-like margin. Asci 20-22μ diam., cylindric, operculate, tapering at the base into a curved pedicel. Spores uniseriate, globose, at first smooth, later the wall becoming reticulate, reticulations 3-6 sided, sides being equal or unequal, areolae

2. See Setchell (loc. cit.), Pl. 15, figs. 1 and 2, and Hennings (7) text figs. 2 and 3.

2 μ deep, and ridges 1μ thick, entire spore 18-20μ diameter; paraphyses simple, septate, clavate, 4-6μ diam. at tip, and filled with orange granules.

On the ground in open places or in moss, near Castlemaine, Vic., and at Ringwood, near Melbourne, Vic. (E. McLennan), August and September, 1921.

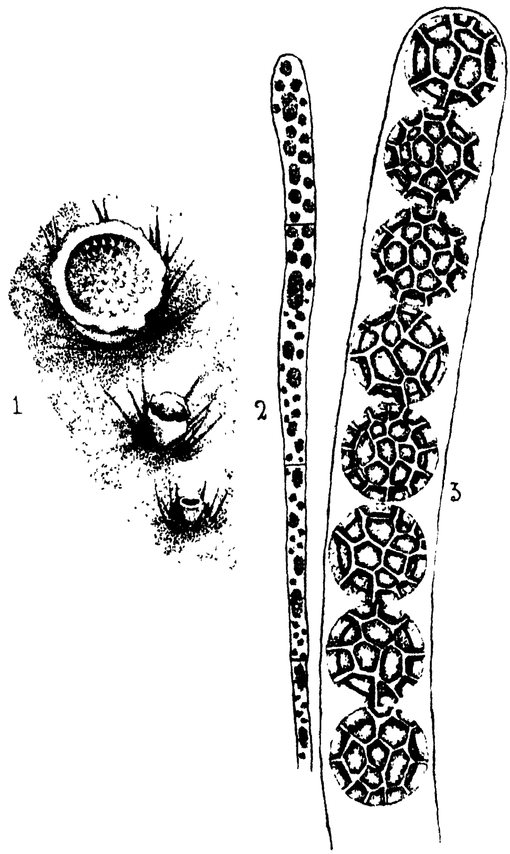


FIG. 1.

1. Plants of **Lamprospora areolata**, Seaver, var. Australis, var. nov.
2. Paraphysis × 750.
3. Portion of ascus × 750.

The plate above described very closely resembles the form *L. areolata*, Seaver (9 and 10), both in the size of the spore and the nature of the spore marking. It, however, differs in its size, and in the possession of a well-marked fringe at the margin of the apothecium [Text fig. I., fig.I.] such a structure being entirely absent in the latter

species. The differences, however, appears to be varietal rather than specific in character, and lead us to regard the Australian representatives of this species as a variety of the American type.

LAMPROSPORA TUBERCULATA, Seaver

Ringwood and Castlemaine, Victoria, E. McLennan, September and October, 1921.

This form is recorded here as new for Victoria, and the plants examined coincide exactly with the description given by Seaver (9 and 10) of the American form. All their characters closely resemble those of a Tasmanian plant *Barlaea verrucosa*, Rod. (11) and it is probable that they are identical since Seaver regards the genus *Lamprospora* as embracing forms described under the generic name *Barlaea* [Sacc] and is defined by him as including "the smaller plants of the globose-spored type of operculate Discomycetes, except those which are commonly placed with the *Ascobolaceae*."

L. tuberculata, Seaver, and *L. areolata*, Seaver, var. *australis*, McL. and C., occur in the same localities, and close to one another. In the field they are quite indistinguishable, their external appearance being identical; it is only after microscopic examination reveals the spore characters that we are able to distinguish the two forms.

IV. CORDYCEPS FURCATA, sp. nov. (Plate X.).

Stromate simplici, stipite trifido. Aerio stipite brevi rubro-fusco transverse fasciato, 6 mm. longo, 2 5 mm. lato, in tres pares et breviores ramulos sursum diviso, qui capitula fertilia gerunt. Capitulo clavato ovoideo rubro fusco 4-5 mm. longo, 2·5 mm. lato, in rostellum sterile desinenti. Peritheciis penitus immersis Ascis linearibus, capitatis. Sporis octo, filiformibus, hyalinis in segmenta baculiformia 8-10 μ longa, 2 μ lata se dividentibus.

Stroma single, entomogenous, stem trifid, continued below the surface of the ground as a root-like structure, 1·7 cm. long, and tapering from 2·5-1 cm. in breadth.

Aerial stem short, stout, red-brown transversly banded owing to the disruption of the outer layer at intervals, and the exposure of the more colourless tissue below, [Plate X., fig. 2] 6 mm. long and 2·5 mm. broad, dividing above into 3 equal, shorter, and more slender branches, each 2·5 mm. long, and 1·5 mm. broad, and bearing a fertile capitulum. Capitulum clavate-ovoid, red-brown, 4-5 mm. long, and 2·5 mm. broad, very faintly punctate with the dark-brown ostiola of the perithecia, terminating in a small sterile, beak-like prolongation, darker brown than the capitulum and 1 mm. long, by ·5 mm. broad.

Perithecia flask-shaped, deeply immersed in the tissue of the stroma [Plate X., fig. 3 & 4], 460-500 μ long, and about 135 μ broad, each opening to the exterior by an ostible visible with slight-magnification as a dark brown circular area on the red-brown surface of the capitulum. Asci linear capitate, 6·5-8 μ broad, Spores 8 filiform soon dividing into numerous rod-like segments, 8-10 μ long, and 2 μ broad, hyaline.

On an undetermined larva at Ringwood, near Melbourne, Vic. (E. McLennan & I. Cookson). September, 1922.

We desire to record our appreciation of assistance given to us by Mr. Laidlaw, B.Sc., Government Botanist and Biologist to the Agricultural Department, who placed the libraries of the National Herbarium and Department of Agriculture (Science Branch) at our disposal, and to Mr. C. C. Brittlebank, Vegetable Pathologist, for his very material assistance and interest in our work.

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EXPLANATION OF PLATES.

Detailed drawings have been made with the aid of the camera lucida.

PLATE IX.

Fig. 1. Plants of *Sphaerosoma alveolatum*, sp. nov. × 4.

Fig. 2. Diagrammatic representation of plant in vertical section. p., peridium; h., hymenium; b., broad basal attachment, × 8.

Fig. 3. Longitudinal section through outer portion of young plant. s., spores. × 103.

Fig. 4. Portion of an ascus, showing spores. × 375.

Fig. 5. Paraphyses. × 375.

Fig. 6. Operculate ascus. × 375.

Fig. 7. Mature spore: × 1125.

PLATE X.

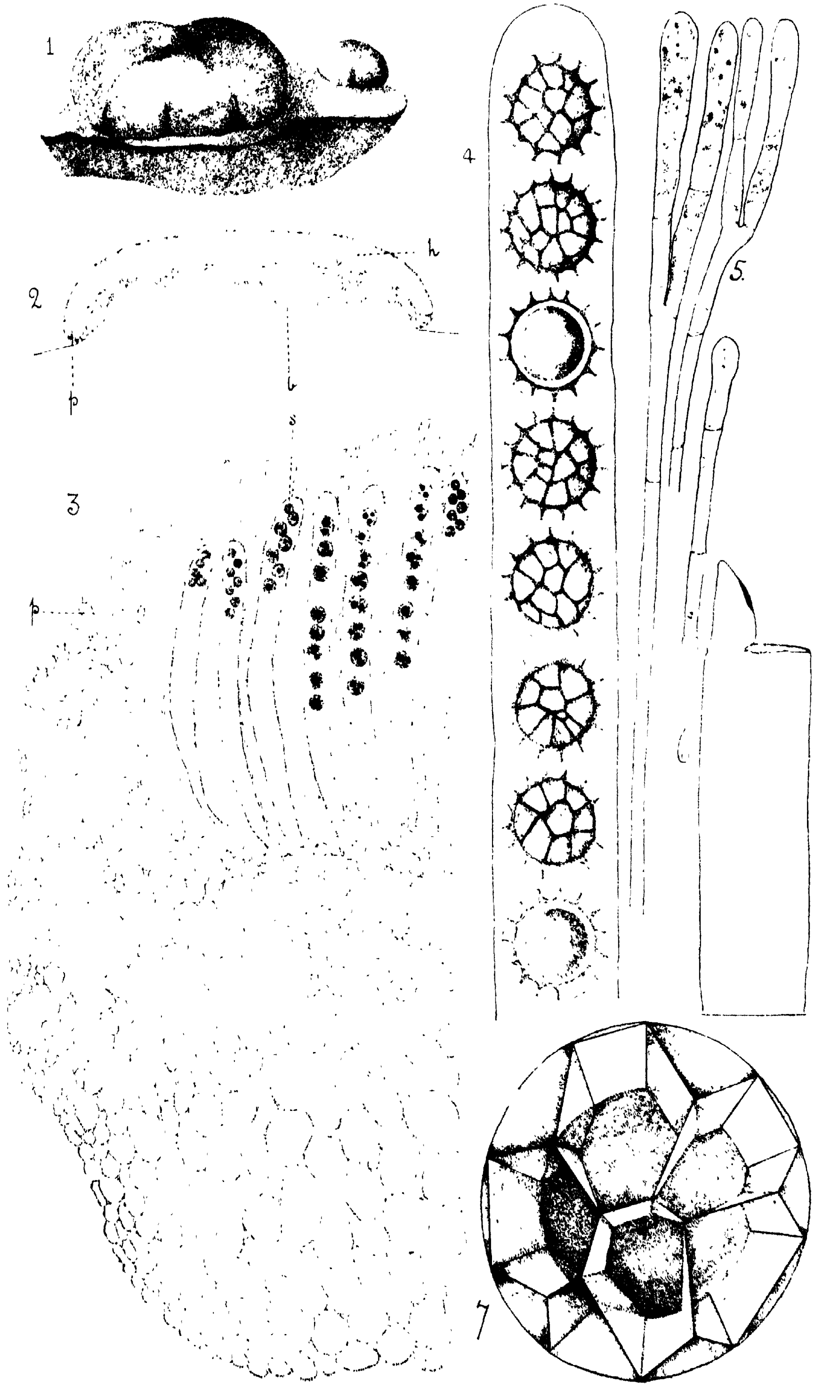
Fig. 1. *Cordyceps furcata*, natural size. g., ground level.

Fig. 2. *Cordyceps furcata*, × 4. g., ground level.

Fig. 3. Longitudinal section through upper portion of capitulum, a., sterile apex. b., ostiole of perithecium. × 23.

Fig. 4. Single perithecium, with asci × 375.

Fig. 5. Portion of ascus. × 750.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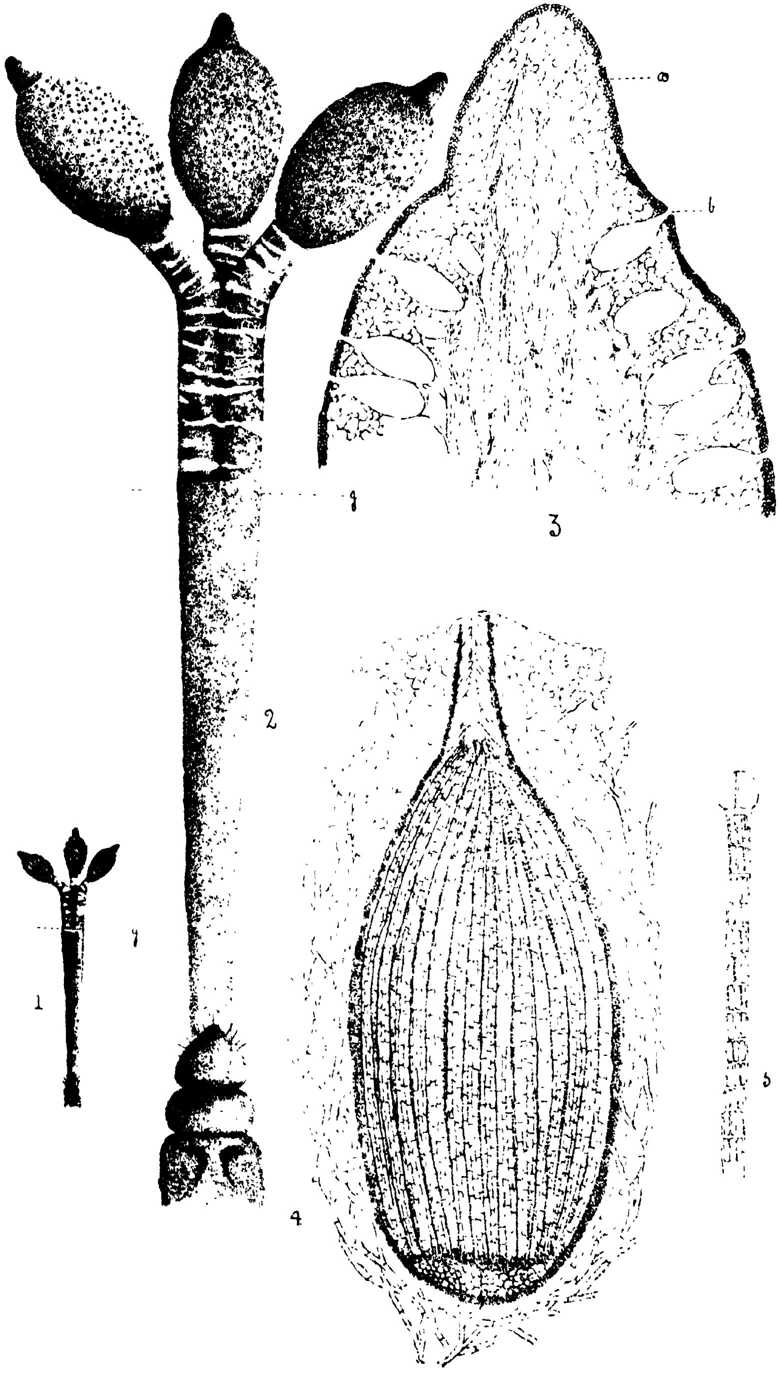
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[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. II., 1923.]

ART. XVI.—*The Specific Identity of Bacillus parabotulinus.*

BY H. R. SEDDON, D.V.Sc.
Veterinary Institute, University of Melbourne.

(Communicated by Professor H. A. Woodruff.)

[Read 9th November, 1922.]

Introduction.

In a previous paper the author[1] has given an account of an anaerobic toxin-forming bacillus, which, whilst resembling *B. botulinus*, very closely in certain respects, yet presented certain characters which were deemed sufficient to warrant the organism being regarded as a distinct species, and the name *B. parabotulinus* was therefore proposed for it.

This organism, *B. parabotulinus*, was recovered from bone of an animal that had died of what, in Tasmania, is locally termed Midland Cattle Disease, but the condition commonly occurs also in at least three States of the mainland of Australia. The condition, further, seems to be identical with Lamziekte of South Africa.

A study of *B. parabotulinus* showed that the administration of bacteria-free filtrates of cultures was followed by the same symptoms as those seen in natural cases of the disease, and the organism was therefore considered to be concerned in the etiology of the condition.

On account of the fact that the symptoms induced are those of progressive bulbar paralysis, the condition was described under the title of Toxic Bulbar Paralysis as it was felt that the geographical and other names used in Australia do not convey a meaning expressive of either the cause or the nature of the condition.

It was shown also that in the horse the administration of toxic filtrates of *B. parabotulinus* lead to symptoms identical with those due to botulinus toxin, whether from human or equine sources, and as Forage Poisoning (Cerebro-spinal Meningitis, so-called) in horse has been shown by several workers in America to be due to Botulism, it would seem possible that there are at least three organisms capable of causing Forage Poisoning in Horses, viz., *B. botulinus*, Types A. and B., and *B. parabotulinus*.

Cases of Bulbar Paralysis in both horses and cattle are of not infrequent occurrence in Australia, but, so far as the horse is concerned, no toxicogenic bacilli have as yet been recovered from suspected fodder. In the case of two outbreaks, however, tests of the blood serum from chronic or recovered cases have indicated the presence of specific antitoxins therein. These were from two widely separated outbreaks, and in the one case it would appear that *B. botulinus* Type A. was responsible, in the other case Type B.

1. Journal of Comparative Pathology and Therapeutics, Vol. 35, 1922, part 3, p. 147.

In the case of cattle, it would appear that *B. parabotulinus* is the common cause and not *B. botulinus*, for though the toxin of this latter organism is capable of inducing symptoms of Bulbar Paralysis, it has been shown by Hart and Hayes[2] that the ox is relatively insusceptible, the administration of massive doses of toxin being necessary to cause symptoms.

In order therefore to determine definitely the relationship of *B. parabotulinus* to *B. botulinus*, investigations have been continued and the results of toxin-antitoxin tests are given below, together with a short summary of the other points of difference between these two organisms.

Comparison of B. botulinus (Types A and B) and B. parabotulinus.

(*a*) *Morphological and cultural characters.*

In the earlier paper it was pointed out that while the two types of *B. botulinus* were identical morphologically and culturally (as is well known), *B. parabotulinus* showed certain differences in that (1) it was distinctly larger, (2) it formed a wholly branched colony in solid media, and (3) it failed to show gas formation in glucose media. It was upon these grounds that the organism isolated here was differentiated from *B. botulinus*.

(*b*) *Toxin formation.*

As is well-known, Types A. and B. of *B. botulinus*, both produce powerful toxins, and these toxins are identical in that they both give rise to the same symptoms, but, as has been pointed out by Graham[3] whereas Type A is highly fatal for chickens (in which it induces Limberneck), Type B. toxin is not. Further it was pointed out many years ago by Leuchs, and has been confirmed by others, that the anti-toxin to one type does not protect against the toxin of the other type, and vice versa.

The bacteria-free filtrates of cultures of *B. parabotulinus* likewise induce symptoms identical with those due to botulinus toxin, and, though exact determinations of relative susceptibility have not been made, it has further been shown that cattle and horses possess much the same susceptibility to these filtrates of *B. parabotulinus* (whereas Hart and Hayes[4] have shown that such is not the case with botulinus toxin). The administration of parabotulinus filtrates to chickens in such experiments as have been as yet performed, indicates their behaviour to be similar to that of the toxin of Type B. *B. botulinus*.

Further work has led to the production of much more powerful filtrates of *B. parabotulinus* than those previously recorded, e.g., of one product subcutaneous injection into a guinea pig at the rate of

2. Journal of the American Veterinary Medical Association, Vol. 57 (10), 1920, p. 638.
3. Journal of Infectious Diseases, Vol. 28, 1921, 317.
4. loc. cit.

0.0005 c.c. per kilogramme body weight led to death in 63 hours, and other products have shown almost as high a titre. Even so it is not believed that the limits of toxicity have been reached, and further enquiry is being made into the factors associated with maximal toxin production.

The evidence presented in our earlier paper that *B. parabotulinus* produced a true toxin was as follow:—

1. The administration of germ-free filtrates lead to symptoms identical with those induced by whole cultures. (These filtrates were obtained after passage of culture through Chamberland F. or Doulton candles, and were tested culturally for sterility.)
2. Such symptoms ensued only after a well marked period of incubation, varying according to dosage and route of administration. This period of incubation was commonly of from 15 hours to several days; even after intravenous inoculation of large doses into guinea-pigs no symptoms were manifested for at least six hours.
3. The administration of small doses of such filtrates sufficed to set up the characteristic symptoms and death.
4. The toxicity of a filtrate was diminshed on heating to 60° C. for 15 minutes and entirely destroying by heating to 80° C. for a like period.
5. The fact that filtrates possessed a toxic property analogous to that of botulinus toxin, i.e., were toxic when administered by the mouth.

It was admitted that as no antitoxin had up till then been prepared against these toxic filtrates, the claim that a true specific exotoxin was present in these cultures could not be wholly substantiated.

Production of Antitoxin.

Repeated attempts have been made to immunise small animals against the toxic filtrates of *B. parabotulinus.* In addition to these two horses have also been employed. The first of these horses had to be discontinued for another cause, and the second horse has received as yet only comparatively few injections; a test of its serum reveals the presence of antibodies, but its serum is as yet of too low a potency for critical experiment.*

At first gradual doses of *unaltered toxin*, starting with a small fraction of a lethal dose, were used, but without success, and the animals (guinea pigs and rabbits) invariably succumbed sooner or later as the doses were increased.

For the next attempt *toxin heated to 60° C. for one hour* was employed for the earlier injections, and by this means, two guinea pigs out of six have been successfully immunised. The remainder of these guinea pigs died during the immunisation process; one of those immunised at one time exhibited marked symptoms of paralysis, from which, however, it gradually recovered; the other likewise showed

* This horse has now been successfully immunised. January, 1923. H.R.S.

slight symptoms, and it is noteworthy that with it the initial injections were very much smaller.

In determining the potency of the toxins employed, the minimal lethal dose (m.l.d.) has been interpreted as the smallest quantity which, administered subcutaneously to a 350 grm. guinea pig, has led to death in less than 48 hours.

The following toxin-antitoxin experiments were performed with the serum from one of these guinea pigs (No. 72). The initial dose for this guinea pig was 1/30th m.l.d. of heated toxin (potency determined after heating); nine injections of heated toxin were given, after which the animal received six injections of non-heated toxin; the last injection, nine days before bleeding, was 40 m.l.d. This guinea pig showed symptoms of paralysis after the third injection (1/10th m.l.d.) in consequence of which treatment was suspended for nearly four months; no symptoms have been shown following the subsequent injections, and at time of killing the animal weighed 900 grms. and was in excellent condition.

In order that cross-immunity experiments might be carried out a polyvalent Botulinus antitoxin has been prepared in a cow (Cow 6) by repeated injection of cultures of both type of *B. botulinus*. The strains used were "B. botulinus A1" obtained from the Lister Institute, through the courtesy of the Director, Dr. C. J. Martin, and "B. botulinus, Type B, No. 40" from Dr. K. F. Meyer's collection, kindly supplied by Dr. Hilda Hempl Heller.

Toxin-Antitoxin Experiments.

In the following experiment guinea pigs of 225 to 270 grms. weight were used, and the test was carried out as follows:—The toxin-anti-

Guinea Pig.	Antitoxin.	Toxin.	Result.
336	Parabotulinus 0·2 cc.	Parabotulinus 50 m.l.d.	Lived.
338	Parabotulinus 0·2 cc.	Botulinus A, m.l.d.	Died second day.
340	Parabotulinus 0·2 cc.	Botulinus B, 1 m.l.d.	Died third day.
337	No antitoxin	Parabotulinus 1 m.l.d.	Died second day.
339	No antitoxin	Botulinus A, 1 m.l.d.	Died second day.
341	No antitoxin	Botulinus B, 1 m.l.d,	Died third day.
342	Botulinus 1 cc.	Parabotulinus 1 m.l.d	Died in 20¼ hours.
344	Botulinus 1 cc.	Botulihus A, 2 m.l.d.	Lived.
346	Botulinus 1 cc.	Botulinus B, 2 m.l.d.	Lived.
345	Botulinus 1 cc.	Botulinus A, 5 m.l.d.	Lived.
347	Botulinus 1 cc.	Botulinus B, 50 m.l.d.	Lived.
343	Serum normal guinea pig	Parabotulinus 1 m.l.d.	Died in 22 hours.

Antitoxins.—Parabotulinus, Serum G.p. 72.
Botulinus (polyvalent), Serum of Cow 6, 13/9/22.

Toxins.—*B. parabotulinus* of 11/9/22. M.l.d. 0·004 cc.
B. botulinus Type A., A1 of 30/9/22. M.l.d., 1 cc.
B. botulinus, Type B., B·40 of 21/7/22. M.l.d. 0·01 cc.

toxin mixtures, made up to a constant volume (3 cc.) with saline were placed in conical glasses, the contents thoroughly mixed, incubated for 1¼ hours at 37° C., and then injected subcutaneously.

In other experiments it has been shown that 0.1 cc. of this parabotulinus antitoxin is capable of protecting against at least 50 m.l.d. of toxin. Even the administration of 100 m.l.d. of toxin, with a similar quantity of antitoxin, was followed by but slight symptoms and ultimate recovery.

It will be noted that the m.l.d. of Type A. botulinus toxin is very large; this was a very weak toxin, and though this strain has a low degree of toxicity much more powerful products have at times been obtained. The dose selected as the m.l.d. for Type B. botulinus toxin was really less than 1 m.l.d., and this is to be ascribed to the toxicity of this filtrate having diminished somewhat since its potency was determined. These factors, however, only serve to make the test more crucial.

The following conclusions are drawn from the above:—

(a) That the antitoxins employed, parabotulinus and polyvalent botulinus protect against their homologous toxins.

(b) That parabotulinus antitoxin fails to protect against either type of botulinus toxin, and conversely a polyvalent botulinus antitoxin fails to protect against parabotulinus toxin.

(c) That normal guinea pig serum possesses no antitoxic value against parabotulinus toxin.
(In another experiment it has been shown that normal ox serum affords no protection against botulinus toxin.)

(d) That, from immunity tests alone, there is sufficient evidence to regard *B. parabotulinus* as being distinct from *B. botulinus*.

Other tests, though not so comprehensive as that given above, have given the same results.

Conclusion.

(1) That *B parabotulinus* produces a true toxin, i.e., a soluble exotoxin obtainable by filtration, producing symptoms only after a definite period of incubation, and capable of inducing the formation of an antitoxin.

(2) That though the toxins of *B. parabotulinus* and of *B. botulinus* are identical in their action, the antitoxin to the one does not protect against the other, and vice versa.

(3) As it has been shown previously that *B. parabotulinus* differs from *B. botulinus* (Types A. and B.), both morphologically and culturally, and is now demonstrated by toxin-antitoxin tests to be distinct, the specific identity of *B. parabotulinus* is claimed.

[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. II., 1923].

ART. XVII.—*The High Frequency K Series Absorption Spectrum of Erbium.*

BY L. H. MARTIN, B.Sc.

(Communicated by Professor T. H. Laby).

(With one Text Fig.)

[Read 9th November, 1922.]

A critical absorption "edge" in the X-ray spectrum of an element has a wave length such that the element absorbs X-rays of shorter wave length than that of the edge, more than X-rays of longer wave length.

For the heavier elements we find one such edge in the K series, three in the L series, and five in the M series[1].

It is found experimentally[2] that if the element previously used as an absorber is now used as a target in an X-ray tube, the K series of this element are emitted only when the voltage applied to the electrodes of the tube equals, or is superior to V_K given by the quantum relation,

$$h\nu_K = \nu_K e$$

where $h = 6.556 \times 10^{-27}$ erg. sec. $e = 1.591 \times 10^{-20}$ e.m. C.G.S. units and ν_K is the frequency of the critical absorption edge, which is also greater than the frequency of the shortest K emission line i.e.,

$$\nu_K > \nu_K\gamma > \nu_K\beta > \nu_K\alpha > \nu_K\alpha' \quad (3) \text{ where } \nu_K\gamma\ \nu_K\beta\ \nu_K\alpha\ \nu_K\alpha'$$

are the frequencies of the K emission lines.

In virtue of these facts, critical absorption phenomena have assumed an important significance in the physical model of the atom as developed by Kossel, Bohr, Sommerfeld, and Wentzel. They are expressions of "levels" of energy within the atom.

It is found that we can form a table of the frequencies of these absorption edges [K; L_1 L_2 L_3; M_1 M_2 M_3 M_4 M_5, etc.] the frequency of every X-ray emission line being expressed as the difference of the frequencies of two edges properly chosen[4], every emission line corresponding to a definite pair of energy levels. We have for example:—

$$K\alpha = L_1 \rightarrow K \qquad L\alpha = M_1 \rightarrow L_1$$
$$K\beta = M_3 \rightarrow K \qquad L\beta = M_2 \rightarrow L_2$$

by which we mean, that the frequency of the K_α line equals the difference between the frequencies of the L_1 and K critical absorption edges, or in terms of our atomic structure, the K_α line is emitted by an atom when an electron falls from the L_1 electron shell to the K electron shell.

The aim of X-ray spectroscopy is then to compile a table of the frequencies for all the critical absorption edges of each element rather than tables of emission line wave lengths. Sommerfeld[5] proposes to call such a table (values of ν/R when R is Rydberg's frequency 3.29×10^{15} sec $^{-1}$) a "term" table. This table will contain for the heavier elements 1(K) + 3(L) + 5(M) + 7(N) + 5(O) = 21 "terms," from definite combinations of which we can determine the values of ν/R for every emission line for each element.

Up to the present terms for elements of atomic numbers 61 → 73 have not been measured, and the purpose of this paper is to show how the K "term" of erbium (N = 68) was determined; soon it is hoped to be able to give the K "terms" for the remaining earths.

X-Ray Spectroscopy.

The analysis of an heterogeneous X-ray beam into its homogeneous constituents is made possible by the "three dimensional" grating formed by the arrangement of the atoms in a crystal. Calcite was chosen as grating crystal because of its relatively large reflecting power, and because it is easier to obtain a calcite crystal which is a perfect X-ray grating than a rock-salt crystal. The grating space "d" is such that with the spectrometer used, the K_α K_{α}' lines of tungsten ($\lambda K_\alpha' - \lambda K_\alpha = 4.81 \times 10^{-11}$ cm.) are resolved with a slit width equal to .12 mm.

A full description of an X-ray spectrometer, similar to that used, was given by Mr. Rogers in these Proceedings, May, 1922, so that here, only those modifications will be described which have been added in an attempt to increase the accuracy of the determinations, and facility with which the apparatus can be used.

The wave length of the erbium K critical absorption edge is approximately $.217 \times 10^{-8}$ cm., so that Bragg's fundamental equation for the diffraction of X-rays by a crystal,

$$\lambda = 2d \sin\theta \quad \cdots\cdots\cdots\cdots \quad (1)$$

can be written, since the angle of reflection of this wave length amounts to approximately 2°,

$$\lambda = c\,\theta \quad \cdots\cdots\cdots\cdots\cdots \quad (2)$$

i.e., the wave length is proportional to the angle of reflection.

When photographing the K absorption edge the crystal was made to oscillate about its axis through 7 mins. of arc by means of a cam driven by an electric motor and reduction gear. This was necessary, as exposures of nearly seven hours were required to obtain a suitable photograph of the edge.

A crystal holder was designed so that the crystal could first be made vertical and then brought into the axis of rotation. In fig. 1. (a) the crystal C is held rigidly by a piece of rectangular tubing A, supported by the main carrier B, at the three points B_1, B_2, B_3, by loosely fitting bolts, rigidity being obtained by three very stiff springs, S_1, S_2, S_3.

The crystal can be brought into the vertical by adjustments of the hexagonal nuts N_1, N_2, N_3, B rests on three ball bearings, two of which move in a V groove, and the third on a flat; the crystal being moved along these, by means of a fine thread screw engaging the carrier B.

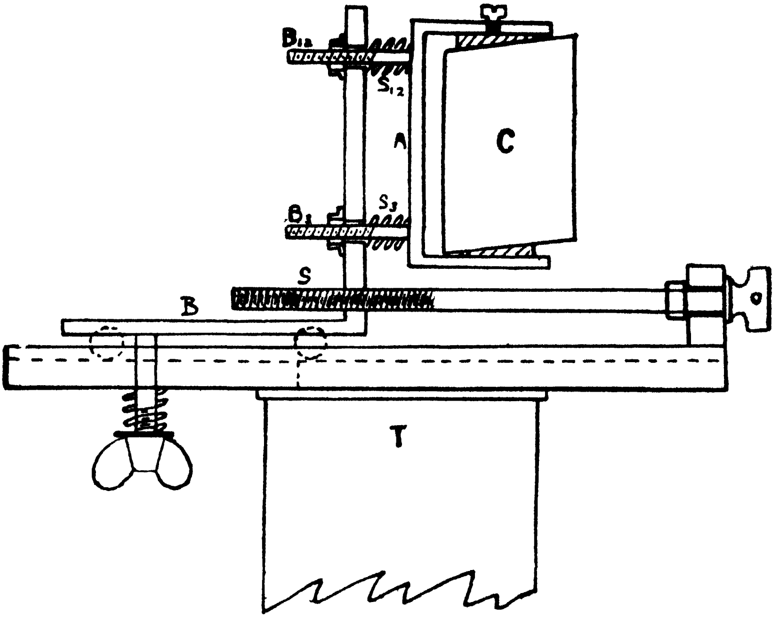

Fig. 1 (a)

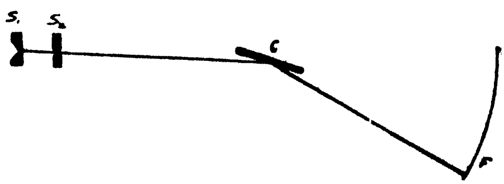

Fig. 1 (b)

Fig. 1 (b) is a diagramatic representation of the disposition of the apparatus. The tube slit S_1, which serves as a fine linear source of X-rays was usually .06 mm. wide. The second slit S_2, serves to limit the angular width of the incident beam. The edges of this slit move in parallel grooves and were arranged parallel to S_1, and symmetrical about S_1, by an optical method.

Adjustments.—The plane of the tube slit S_1 was first adjusted by an optical method to be perpendicular to the radius O S_1 (Fig. 1.) and at the same time vertical.

A reflected image of S_1 was observed in the polished crystal face. The crystal was adjusted as explained above so that the slit S_1 and its image were parallel for all positions of the crystal.

To set the surface of the crystal in the axis of rotation a fine needle point, lying horizontally opposite the middle of the crystal, was observed by a long focus microscope. The needle was adjusted until the point did not move in the field of view when the table was turned through 360° The crystal was brought up until the reflection of the point, and the point itself, just touched when seen under the microscope. In this manner it was possible to set the crystal rapidly so that its middle section coincided with the axis of rotation to within $\pm$ .0005 cm.

In order to ensure that the central ray from the target passes through the axis of rotation, the crystal was set at zero and an X-ray photograph taken of the crystal. If the setting of the target is true, the edge of the crystal lies exactly in the centre of the darkening, which is limited by S_2.

Experiment.— As the erbium K absorption edge could not be distinguished from the K_{α}' line of tungsten, it became necessary to use a Gundelach gas tube with a platinum target as a source of general radiation.

Two millimetres thickness of erbium oxalate were placed before slit S_1, and the absorption edge registered on one half of the film, while the reference tungsten $K\alpha$ $K\alpha'$ lines were placed on the other half. The distances $W_{K\alpha} \rightarrow Er_{KL}$, $W_{K\alpha} \rightarrow W_{K\alpha'}$ were measured by projecting the film (magnification 10) on to a vertical platform, motions of which could be read by a dividing engine screw accurately to .0005 mm. Table I. contains an actual series of displacement measurements.*

TABLE I.

$W_{K\alpha} \rightarrow W_{K\alpha'}$.	$W_{K\alpha} \rightarrow Er_{KL}$.	$\lambda Er_K \times$ units.	$W_{K\alpha} \rightarrow W_{K\alpha'}$.	$W_{K\alpha} \rightarrow Er_K$.	$\lambda Er_K \times$ units.
mm.	mm		mm.	mm.	
1·513	2.353	216-08	1·497	2·346	216·14
1·523	2·398	215·96	1·488	2·343	216·17
1·524	2·386	215·99	1·503	2·349	216·12
1·514	2·356	216·09	1·508	2·358	216·12
1·515	2·366	216·09	1·497	2·363	216·19
1·512	2·350	216·07			

* The method, suggested by Professor Laby, developed in this laboratory for measuring these small displacements has been described previously by J. S. Rogers, M.Sc. (l.c.).

The values $W_{K\alpha} = 208.60 \times 10^{-11}$ cm., $W_{K\alpha'} = 213.41 \times 10^{-11}$cm. are those of W. Duane and W. Stenstrom[6], which lead to a value for the erbium K absorption edge.

$$\lambda Er_K = 215.9 \times 10^{-11}\text{cm.}$$

Pl. 2.	Oct. 24.	$\lambda = 216.09 \times$ units.		Weight 1.
Pl. 4.	Nov. 16	$\lambda = 215.85 \times$ units.		Weight 2.
Pl. 5.	Nov. 21.	$\lambda = 215.87 \times$ units.		Weight 2.

Weighted mean $\lambda = 215.9 \times 10^{-11}$ cms.
Term value (ν/R units) = 4222.

Discussion.

In the determination of the wave lengths of such penetrating rays as the above, we are beset with the difficulty, that, owing to crystal penetration the effective plane of reflection lies below the surface of the crystal. If θ is calculated from the geometrical properties of the apparatus, and the distance of "edge" from direct ray impression, an error is introduced amounting to nearly 3% in short wave length determinations. Errors of this magnitude are observed in the K absorption edge determinations of de Broglie[7] for elements Hg to U.

In this method, which might be called a method of coincidences, the reference rays and the erbium K absorption edge have sensibly the same wave length, and the result is free from this objection.

Determinations have been made by Duane and Blake[8], using an ionisation chamber method in which θ was read directly from an accurately divided circle, and by Siegbahn and Jonsson[9], using a photographic method, both of which are free from the above source of error. Siegbahn and Jonsson used their crystal as a transmission grating, a method first devised by Rutherford[10] for his determinations of the wave length of the penetrating γ rays of RaC, the rays being constrained by slits to meet the plane of reflection passing through the axis of rotation.

Although both methods are free from objection, the values obtained by Sieghahn and Jonsson are systematically smaller than those obtained by Blake and Duane for the absorption edge wave lengths of the K series.

Extrapolating the two series of values for the value expected for erbium we find—

Siegbahn and Jonsson $\lambda = 215 \times 10^{-11}$ cm.
Blake and Duane $\lambda = 216 \times 10^{-11}$ cm.

The value found here 215.9×10^{-11} cm. agrees better with the results of Blake and Duane. Duane has suggested that the discrepancy may be found in that Siegbahn probably measured from the point at which darkening began, instead of the point corresponding to the centre of the slit. Here that settings were made for those rays which correspond to the centre of the slit.

I wish to thank Professor Laby for his valuable advice and interest during the execution of this work. I am also very much indebted

to Welsbach and Co., U.S.A., for a very pure sample of erbium, which they presented to the Natural Philosophy Dept. X-ray analysis showed that there was no discernable impurity.

References.

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(2) D. L. Webster, Physical Review 7, 599, 1916.
(3) D. L. Webster, (l.c.).
(4) Coster, Zeitschr. f. Phys. 185, 1921.
(5) Atombau und Spektrallinien, 3 ed., 1922.
(6) Proc. Nat. Acad. 6, 477, 1920.
(7) Journ. de Phys., 1916.
(8) Phys. Rev., 14, Dec., 1919.
(9) Phys. Zeitschr., 20, p. 252, 1919.
(10) Phil. Mag. 28, p. 266, 1914.

[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. II., 1923.]

ART. XVIII.—*The Austral Rhynchonellacea of the "Nigricans Series," with a special description of the new Genus Tegulorhynchia.*

BY FREDK. CHAPMAN, A.L.S., and IRENE CRESPIN, B.A.

(With Plates XI-XIII.)

[Read 14th December, 1922.]

Contents.

I.—Introductory.

Since the phylogenetic relationships of the Cainozoic rhynchonellids belonging to the "*Hemithyris nigricans* series" of Buckman[1], of the Australasian (Southern Victoria and New Zealand) and other con-

1. Buckman, 1910, p. 13.

tiguous areas of the southern hemisphere do not seem to have been satisfactorily defined, the opportunity is now taken, with the help of a great deal of new material, to review the evidence already published. This, we hope to show, will prove that the southern stock of these multiplicate Cainozoic and Recent forms is generically distinct from *Hemithyris*, and seems to have been derived from a common Mesozoic type long before the period of the disintegration of the early Antarctic continent.

Until 1910, the Australian rhynchonellids, both fossil and recent, were referred to the genus *Rhynchonella* in the unrestricted sense. In that year, Mr. S. S. Buckman published a paper on Antarctic Fossil Brachiopoda[2], in which he described several fossil forms of rhynchonellids, two of which had been previously recorded under the genus *Rhynchonella* (*R. squamosa*, Hutton, and *R. plicigera*, Ihering). These fossil forms Buckman referred to d'Orbigny's genus *Hemithyris*, which in the original description is stated to possess no dental plates.

In 1914, one of us[3] referred to Hutton's species, *squamosa*, as belonging to the genus *Acanthothyris* of d'Orbigny, on account of the tendency of this form to develop a spinose character along the costae. This spinose character is fundamental in d'Orbigny's Jurassic genus. The genotype of *Acanthothyris* is *A. spinosa*, Schlotheim sp. of the Inferior Oolite of England[4]; but, as we hope to show later, the northern Jurassic and the southern Cainozoic forms belong to different stocks, and therefore the spinose character is an example of convergence of form.

In his revision of the Fossil Brachiopoda, Prof. Chas. Schuchert[5] had included the living spinose form, *Rhynchonella doederleini* of Davidson[6], as a representative of the genus still living in Japanese Seas. From the present evidence this species seems related to the southern types, which fall into the new genus *Tegulorhynchia*.

In reviewing all the evidence given by previous authors, and in the light of a large amount of material recently collected from Victorian and other Australian deposits, we find the results necessitate the establishment of a new genus which will include forms of the *Rhynchonella squamosa* type, the distinctive characters of which are discussed in a later section.

II.—Cainozoic and recent Austral Rhynchonellids: With Critical Notes.

antipoda, **Hemithyris, Thomson.**

Thomson, 1918[2], p. 117.

> "In *H. antipoda*, the ribs are similar in size to *H. nigricans*, but rather more numerous, and are incipiently spinose."

2. Buckman, 1910, pp. 10-14.
3. Chapman, 1914, pp. 166, 167, fig. 89F.
4. cf. Davidson, 1852, p. 71, pl. xv., figs. 15-20.
5. Schuchert, in Zittel, 1913, p. 400.
6. Davidson, 1887, p. 172.

From specimens kindly lent us by Dr. Thomson from New Zealand, we note that the species *antipoda* differs from *thomsoni* in having a more salient beak and several strong, concentric growth-lines, especially seen on the dorsal valve.

Miocene.—Curiosity Shop, Rakaia River, Canterbury, N. Z.

australis, Hemithyris, Buckman.

Buckman, 1910, p. 12, pl. I., fig. 11.

This smooth, sub-pentagonal form is referred by Buckman to the *Rhynchonella bipartita* series. From its more erect form of beak and even growth-lines, it is possibly a distinct form from the boreal, living hemithyrids; although related forms are known from the Eocene and Miocene of Europe, and *R. lucida* is living in Japanese Seas. It belongs to the hypothyrid section, as pointed out by J. Allan Thompson[7], otherwise it is similar to Thomson's generic form, *Aetheia*.

Miocene.—Glauconitic Bank, Cockburn Island, Graham Land.

coelata, Rhynchonella, McCoy (in Tenison Woods).

Woods, J. E. T., 1878, p. 77.

Generally referred to as an Ms. name of McCoy's. T. Wood's gives a short description of the shell, which places beyond doubt its identity with our common Victorian form, (see *postea*).

"From several Miocene beds in Victoria," Miocene (Janjukian).

colurnus, Hemithyris, Hedley.

Hedley, 1905, p. 44, text-fig., 7, 8.

The nearest ally is *Hemithyris beecheri*, Dall, found in 313 fathoms at Honolulu. This is a triangular, cordate form, smooth, except for faint growth-lines. From the distinctly epithyrid foramen, this species appears to belong to Thomson's genus *Aetheia*.

Recent.—Dredged at 111 fathoms, East of Cape Byron, New South Wales.

depressa, Hemithyris, Thomson.

Thomson, 1918, p. 117.

A small species with short beak. "Possesses numerous fine ribs with imbrication towards the margin."

Miocene (Ototaran and Lower Hutchinsonian stages). —One mile north of Kakanui Quarry, Oamaru District.

doederleini, Rhynchonella, Davidson.

Davidson, 1887, p. 172, pl. XXV., figs. 14, 15, text-fig. 19.

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7. Thomson, 1915, p. 390.

Appears to show some interesting annectant characters of the tubular-spined Miocene forms found in Australian deposits.

Recent.—Dredged, Sagami Bay, Japan, in about 160 fathoms.

gerlachei, Rhynchonella, Joubin.

Joubin, 1901, p. 7, pl. I., figs. 5-9; pl. II., fig. 10.

A suboval form with smooth shell, but for faint growth-lines. The beak is erect and deltidial plates are very narrow. It belongs to the *Rhynchonella bipartita* group.

Recent.—Antarctic Seas.

imbricata, Hemithyris, Buckman.

Buckman, 1910, p. 11, pl. I., fig. 12.

Apparently nearly related to some well preserved rhynchonellids from Table Cape, Tasmania, which we have named *Tegulorhynchia coelospina*.

Miocene.—Glauconitic Bank, Cockburn Island, Graham Land.

nigricans, Terebratula, Sowerby.

Sowerby, 1846, p. 342, pl. LXXI., figs. 81, 82.

(*Rhynchonella*). Suess, 1864, p. 60, pl. XIV., figs. 4*a*-*d* (expl. of plate 5*a*-*d* in error).

This living and fossils species is a modification of the *squamosa* type, in which the shell is more terebratelloid in form and the ornament less distinctly tegulate.

Miocene.—Oamaruian and Awamoan, New Zealand (Hutton).

Recent.—Coast of New Zealand, in 19 fathoms.

nigricans, var. *pyxidata*, Rhynchonella, Davidson,

Davidson, 1880, p. 59, pl. IV., fig. 14. Id., 1889, p. 171.

This form has been compared by Davidson (op. cit. 1880, p. 60), with McCoy's *R. coelata*, but which we consider distinct.

Recent.—Dredged south of Kerguelen Island, at 150 fathoms, rocky sea-bottom.

patagonica, Rhynchonella, Ihering.

Ihering, 1903, p. 334, pl. III., figs. 11*a*, *b*.

Figures given by Ihering are not very clear, especially as regards ornament, but that difficulty is removed by Ortmann's figure of *R. squamosa*, which is accepted by Ihering as identical with *R. patagonica*. In the description of *R. patagonica* by Ihering it is pointed out that the species differs from *R. squamosa*, Hutton (non Ortmann) in having a larger number of costal rays. We also note that Ortmann's specimen shows about 12 costæ on the sinus, and Ihering mentions 15.

Miocene.—Lake Pueyrredon (Ortmann). Rio Seco and San Julian (Ihering). Patagonia.

plicigera, Rhynchonella, Ihering.

Ihering, 1897, p. 270, text-fig. 7.

Id., 1903, p. 334.

Ortmann, 1901, p. 70, pl. XII., figs. 3*a-e*.

This species by its coarse plication, transverse shape and anterior tegulation, closely approaches our new species, *Tegulorhynchia thomsoni*.

Miocene (Lower, Middle and Upper Patagonian). Patagonia.

plicigera, Hemithyris, Buckman (non Ihering).

Buckman, 1910, p. 12, pl. I., fig. 10.

This species appears to differ from Ihering's *R. plicigera* on account of the narrow form of valves and character of ornament, which appears to be confined to the anterior margin.

Miocene.—Glauconitic Bank, Cockburn Island, Graham Land.

racovitae, Rhynchonella, Joubin.

Joubin, 1901, p. 5, pl. I., figs. 1-3.

A smooth, sub-pentagonal hypothyrid rhynchonellid, with only faintly sinuated anterior.

Recent.—Antarctic Seas.

squamosa, Rhynchonella, Hutton.

Hutton, 1873, p. 37.

A suborbicular, finely ribbed form, tending to become elongated vertically, rather than transversely. The topotype from New Zealand shows the species to be distinct from the Victorian one, which we now refer to *T. coelata*, T. Woods sp.

(?) Oligocene (Ototaran stage), Broken River, New Zealand.

striata, Hemithyris, Thomson.

Thomson, 1918, p. 11, pl. XVI., figs. 30, 31, 32, 45.

This appears to belong to the *Hemithyris bipartita* group. Thomson suggests that it is the adult form of the *Hemithyris* (*Frieleia*) *gerlachei*. It is quite distinct from the *Tegulorchynchia* type of the *nigricans* series by the fine radial ornament and lack of folding, as pointed out by Thomson. The short beak is rather striking as in that character it agrees with the *nigricans* type, excepting for the small foramen.

Recent.—Off Shackleton Glacier, Davis Sea, at 358 fathoms.

sublaevis, Hemithyris, Thomson.

Thomson, 1918, p. 117.

"Narrowly and strongly folded and possess numerous fine ribs, little imbricated, and in many specimens almost obsolete."

Miocene (Ototaran stage).—Everett's Limestone Quarry, Kakanui, Oamaru District.

tubulifera, (?) Rhynchonella, Tate.

Tate, 1899, p. 257, pl. VIII., figs. 4, 4*a*.

Tate says, "*R. tubulifera*, if juvenile, is indicative of a much less gibbous shell" (than *R. squamosa*) "in the adult stage." This, although a minute form, is apparently mature, as it shows the contour of a fully developed rhynchonellid.

Oligocene.—(?) Lower beds, Muddy Creek. Victoria.

Miocene.—Polyzoal Rock, Muddy Creek, Victoria.

A note on the European Rhynchonellid erroneously referred to the **Australian Cainozoic Fauna** as *Rhynchonella baileyana*. (See Plate I., figs. 14, 15).

References.—Tate, 1885, pl I. Id., 1886, p. 94, pl. VI., figs. 3*a*-*c*. Id., 1899, p. 257.

This species was recorded by Tate in 1885, as occurring at Jemmy's Point, Gippsland Lakes, and collected by Mr. J. F. Bailey.

At the time of description, Tate seemed to suspect that it was anomalous as a Tertiary species, for he remarks that it recalls some Mesozoic ones, and adds, "I do not know of any other fossil which has so depressed and broadly oval form, conjoined with marginal plications and small suberect beak as it possesses."

In 1899, Tate added a note for this species (p. 257), and said, "My surmise of its Mesozoic origin is confirmed by Mr. R. Etheridge, jnr., who attributes it to the Cretaceous of Faxoe." We have examined an extensive series of Cretaceous Rhynchonellae in the National Museum, and these, together with a comparison of Davidson's figures in his Cretaceous Memoir, proves that the above form belongs, not to a Danian rhynchonellid, but to a well-known form of the Senonian Chalk, found in England, and on the Continent. That species is *Cyclothyris limbata*, Schlotheim sp., of which the following is the principal synonymy.

Terebratulites limbatus, Schlotheim, 1813, p. 113 (Faujas, 1799, pl. XXIV., fig. 4).

Terebratula subplicata, Mantell, 1822, p. 211, pl. XXVI., fig. 5.

Rhynchonella limbata, Schlotheim sp., Davidson, 1854, p. 79, pl. XII., fig. 1-5.

We are much indebted to Professor Sir Douglas Mawson for his kindness in allowing us to see the specimen in the collection of the Adelaide Museum, and we have taken this opportunity of giving a photograph of it, as well as of a typical specimen from the Senonian of Ciply, Belgium (Nat. Mus. Coll.).

III.—Description of Teguiorhynchia, sp. nov. Genotype "Rhynchonella squamosa," Hutton.

(a).—Definition.

Ventrally uniplicate, generally wider than high; shell moderately stout; typically with a strong undulate and tegulate ornament, cor-

responding to growth-lines which cross the ribs that are typically constant on valves. By structural specialisation the tegulation becomes tubular, and eventually links up with that seen in *Tegulorhynchia doederleini*. Beak hypothyrid; as seen in edge view erect, usually truncate or only slightly incurved. Deltidial plates strong and tpyically equilaterally triangular. Dental plates well defined and strong, the septum represented on inside of dorsal valve, by a very thin plate which extends to nearly one half of the length of the shell. Muscle areas on interior of the dorsal valve are well marked and sub-quadrate, and fairly large.

(b).—Distinctions from *Hemithyris*.

According to Professor Schuchert, *Hemithyris* is defined as "smooth or faintly plicate rhynchonellae with a high ventral beak and open delthyrium. No dental plates." As a matter of fact, dental plates are present in the genotype *Hemithyris psittacea*, Chemnitz sp., the typical northern form, as indicated by Davidson, Dall and Thomson (see pl. I., fig. 13; pl. II., figs. 16, 19).

So far as we have seen, these dental plates are always slender and not well developed. On the contrary, the forms of the southern *R. nigricans* series are stout and strong compared with the northern *Hemithyris*. The type of *Hemithyris*, d'Orbigny (*Rhynchonella psittacea*) has[8] a "beak sharply pointed and incurved." *R. squamosa* has it erect and more often quite blunt.

In regard to the ornament, *Hemithyris* is typically smooth, or striate, never distinctly costate, so far as we have seen from the specimens in the National Museum collection, which were dredged from the North Sea. In these example, also, the growth-lines are purely concentric and never tend to become strongly undulose or overlapping to the extent of even a form like the living *nigricans*. In *Hemithyris* the septum is rudimentary, low, and barely extending halfway across the shell. In *Tegulorhynchia* the septum is more strongly developed, and extends into the anterior half of the shell. The deltidial plates in a typical *Hemithyris psittacea* are elongated in the form of a scalene triangle, whereas in *Tegulorhynchia* they are almost, to quite, equilateral. These plates are strongly discrete in *H. psittacea*, whereas in *Tegulorhynchia* they may be only slightly so (*T. coelata*), or conjunct (*T. squamosa*).

(c).—Phylogeny of the Genus.

From the widely spread occurrence of the Tertiary rhynchonellids of the *squamosa* type in the southern hemisphere, it is only natural to conclude that these forms sprang from some already well established ancestor in the Mesozoic.

Of the recorded Mesozoic species found in Australia we have:—

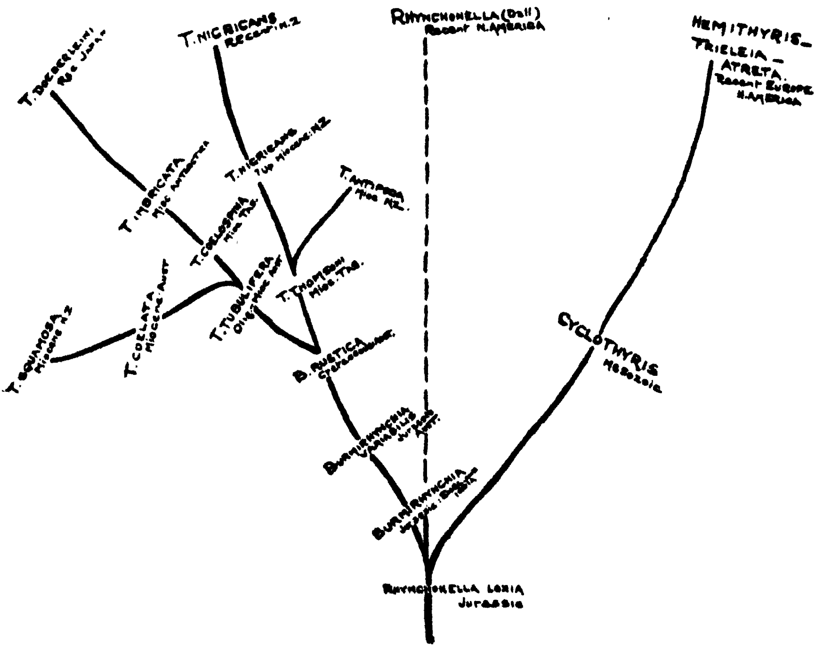
Rhynchonella croydonensis, Etheridge, fil., 892, p. 560, pl. XLI., figs. 13, 14.

8. Davidson, 1887, p. 164.

In this the shell is transversely elongate, the dental plates are short, strong and somewhat curved. The lateral areas have six prominent angular ribs; the median sulcus carries four fainter costae. There are traces of distinct transverse lamellae. We are inclined to think that the two figures represent different species, since the ventral valve (fig. 13) has the deep sulcus and prominent beak of Buckman's genus *Kallirhynchia.* Figure 14, if shown by additional specimens to be distinct, might be re-named *Burmirhynchia etheridgei.*

Occurrence.—Cretaceous. Croydon Goldfields, Queensland.

PHYLOGENY OF THE AUSTRAL AND RELATED RHYNCHONELLACEA.



Rhynchonella eyrei, Etheridge, fil., 1902, p. 8, pl. I., fig. 2.

Triangular; costae prominent and coarse, three to four on fold; two to three on the sinus, and three to four on either side. The valves are crossed by numerous, concentric frilled laminae.

Occurrence.—Lower Cretaceous. Central South Australia.

Rhynchonella rustica, Moore, 1870, p. 245, pl. X., fig. 79.

The shell is wider than long, with 20 to 25 costae. The beak is acute and compressed when young. The sur-

face is covered with striae, 20 to 25 in number, which in the adult stage are wavy and irregular.

Occurrence.—Lower Cretaceous. Queensland.

Rhynchonella solitaria, Moore, 1870, p. 245, pl. X., fig. 10.

The shell is wider than longer, with four widely spreading costae, and a single lateral costae on either side of the sinus. Costae evanescent towards the umbo.

Occurence.—Lower Cretaceous. Queensland.

Also Jurassic, Geraldton (cf. *solitaria*,—fide F. C. in Nat. Mus. coll.).

Rhynchonella variabilis, Schlotheim, Moore, 1870, p. 231-232 (list), pl. X., figs. 11, 12.

Shell as high as broad, about 9 costae, which are plicated towards the anterior commissure.

Occurrence.—Jurassic. Geraldton District, W. Australia.

With regard to these Mesozoic Australian rhynchonellids it is interesting to note that one of the forms from the Lower Cretaceous, viz., *R. rustica*, agrees with the general form of the Miocene and later *Tegulorhynchiae*. The shell is wider than long, though the transverse character is not absolutely uniform, but predominant. The numerous costae also form another factor for comparison, although the riblets in the later Tertiary and living forms tend to become less numerous and less acute. The beak in *Rhynchonella rustica* is said to be acute and compressed when young. In his description of *R. rustica*, Moore compares the Australian Cretaceous form with *R. concinna* of the Great Oolite and Bradford clay of England which, he says, "it approaches more closely." From the excellent figures of *R. concinna* given by Davidson[9], it will be seen that the delthyrium is almost exactly comparable with that in *Tegulorhynchia*, for the deltidial plates are disjunct and are almost equiangular, and in no way could *R. rustica* on this evidence be compared with the Cretaceous genus *Cyclothyris*. *R. rustica* may also be compared with the compressed and almost truncated beak in *Tegulorhynchia*. Two other forms, both from the Cretaceous of Central South Australia and Queensland respectively, are *Rhynchonella eyrei* and *R. croydonensis*. Both of these have the ornament characterised by the prominent growth-lines which cross the riblets. In *R. eyrei* these are developed into distinct laminae, and in *R. croydonensis* they also occur, but are less distinct, and more distantly placed.

In "*Rhynchonella*" *variabilis* we have a type of shell which is coarsely plicate, but the entire form of the shell is closely comparable with the variants of *Tegulorhynchia squamosa*, as we have them represented at Waurn Ponds and Keilor. The dorsal valve in these forms, is strongly ventricose, and the ventral valve is subplanate. In regard to the beak in *R. variabilis*, this is not prominent, and the apex varies from being slightly incurved to almost truncate. This seems to suggest the possibility, when compared with the other

9. Davidson, 1852, pl. xvii., figs. 6-12.

forms of beaks in Mesozoic rhynchonellids, that there is a direct relationship in this part of the structure with the Tertiary forms. The foramen also in "*R. variabilis* is distinctly hypothyrid and sub-elliptical, and the deltidial plates, though small, are very similar in shape to those of *Tegulorhynchia.* "*R.*" *variabilis* has the conjunct type of deltidial plates, whereas in the form of *Tegulorhynchia* they are almost invariably disjunct (exception, *T. Squamosa*).

(d).—Variation in Time.

The majority of the Jurassic and Cretaceous forms in Australia (*R. rustica, eyrei, croydonensis*-pars, *solitaria* and *variabilis*) agree in their main characters with Buckman's *Burmirhynchia.* His definition, taking *Burmirhynchia gutta,* nov. as type is[10]—"hypothyrid (beak massive, springing from a gibbous umbo, apex produced and incurving [foramen sub-elliptical, deltidial plates narrow, disjunct]); slightly trilobed; multiplicate; dental plates strong, much divergent; ventral muscle area large, pyriform; dorsal septum strong; dorsal muscle area quadriform to subcircular pattern, the two anterior scars strongly marked, making a cordate figure, being individually more or less pyriform, bounded by well-marked, diverging channels."

In these early forms the dorsal septum is strong. The later, Tertiary and living representatives, have a low dorsal septum, but extended, probably pointing to an ancestral feature of greater development. The dorsal muscle areas agree in shape both in the Indian and Australian Jurassic, and also in the Australian Tertiary types, though in the latter they are of greater extent.

In some of the earlier Mesozoic forms the beak has already been modified by truncation; that is to say, less incurved and prominent. The deltidial plates are disjunct, both in *Burmirhynchia* and *Kallirhynchia,* and these show features ancestral to the austral form, but common to both. The tegulate character is seen developing in the early forms to some extent, but not until the Miocene is it well pronounced.

(e).—Palaeographical Factors.

The *Burmirhynchia* type of shell was already established in the Lias, Inferior Oolite and Greater Oolite of England, and the Continent. It appears to have migrated along a possible shore-line in Upper Jurassic times, judging from the community of Upper Jurassic types of mollusca and brachiopoda seen in the Western Australian beds, where foraminiferal species are also common to both areas.

During this time also, the terrestrial areas were continued, forming a favourable geographical unit from Europe across to India, and thence to Australia. Many Jurassic invertebrates of the Indian area are common to Australia. The interesting fact is here brought out, that of the later type of rhynchonellid, the genus *Cyclothyris* appears to be absent thus far, and our Australian Cretaceous species

10. Buckman, 1917, p. 49.

are of the Jurassic type, which eventually passed into the type, *Tegulorhynchia*—"*nigricans* series"—of the Cainozoic and recent deposits of Australia, New Zealand, Patagonia and Antarctica.

(f).—Evidence of Bathymetrical Habitat.

The majority of the living brachiopods are, as Schuchert has already pointed out[11], deep water and abyssal, and they are practically all thin-shelled.

The present habitat of the living *Tegulorhynchia nigricans* gives a good idea of the probable average depth of the earlier tegulate forms, having a similarly thick shell. It has been recorded 5 miles east of Ruapuke Island in 19 fathoms, on rock and coral; also from Chatham Island. The range given by Canon Norman for the boreal *Hemithyris psittacea* is 10-690 fathoms, at Shetland and near the Dogger Bank. Reeve gives the range from low water to 100 fathoms.

In regard to the living form, *T. doederleini*, this was dredged in about 160 fathoms.

Fischer, in his Manual[12] separates the zone of Brachiopods and Corals, as occurring from 72 to 500 metres in depth (36-250 fathoms). He quotes Macandrew, who dredged *Hemithyris psittacea* from near Finmark, at a depth of 121 to 165 fathoms, in sand.

The group of the genus *Tegulorhynchia*, now discussed, is, generally speaking, thick-shelled. Moreover these forms are associated with shore-loving forms, as at Keilor, near Melbourne, and Table Cape, Tasmania; or in fairly deep water limestones, as at Batesford, near Geelong. In the former case the shells are typically incrassate, whereas in the deeper water habitat they are slightly thiner in build. Instances of the genus in still deeper habitat are found at Fishing Point, Cape Otway, and in the Lower Muddy creek beds.

IV.—Description of the Species of Tegulorhynchia.

1.—TEGULORHYNCHIA SQUAMOSA, Hutton, sp.

(Pl. I., figs. 1, 2; pl. II., fig. 22; pl. III., fig. 26.)

Rhynchonella squamosa, Hutton, 1873, p. 37.

Hemithyris squamosa, Hutton, sp., Buckman, 1910, p. 10, pl. I., fig. 13.

Hemithyris squamosa, Hutton, sp., Thomson, 1918, pp. 108 and 117.

Description.—"Shell irregular, more or less orbicular; valves inequal, the ventral flatter, and with a deep groove; dorsal valve very convex; both with find radiating scaly striae. Length, .7 mm.; breadth, 7.5 mm.; height, .5 mm."

Observations.—From a topotype which has been kindly presented to the National Museum by Dr. J. A. Thomson, we note that this

11. Schuchert, 1911, p. 226.
12. Fischer, 1887, p. 188.

species tends to be greater in length than width, although there are exceptional cases where it is slightly wider than long. The beak is much higher than in *T. coelata*, and the deltidial plates are conjunct. The plication is at once seen to be much finer in character than in the Victorian species, *T. coelata*, which in some other respects it resembles. It will be appropriate here to append a synopsis of the average number of plicae which we have counted on the ventral sinus of the principal species of the genus *Tegulorhynchia*.

Species.	Average number of plicae on sinus of ventral valve.	Range in Time.
T. patagonica, Ihering sp.	12 to 15	Oligocene or Miocene (Patagonia) Buenos Aires.
T. squamosa, Hutton, sp.	10	(?) Oligocene, New Zealand.
T. coelata T. Woods, sp.	8	Miocene. Victoria, South Australia and Tasmania.
T. thomsoni, sp. nov.	6	Miocene. Tasmania.
T. nigricans, Sow, sp.	4	Upper Miocene to Recent. New Zealand.

Pedicle foramen, long-ovate and well elevated above the cardinal margin, the height being occasioned by the conjunct character of the deltidial plates. The elevation of these plates in some specimens is accompanied by a low, crescentic cavity between the cardinal margins of the ventral and dorsal valves. Viewed in profile, from the anterior aspect, the tegulation in *T. squamosa* seems to be largely confined to the ribs, whereas in *T. coelata* the tegulation is continuous over the ribs and intercostal areas. The discrepant growth-lines in *T. squamosa* are not so strongly marked as in *T. coelata*, and from that we may infer that *T. squamosa* is the older type, compared with *T. coelata*, the latter connecting with *T. nigricans* in this particular character of tegulation.

Occurrence.—(?) Oligocene (Ototaran stage). Broken River, New Zealand.

Miocene. Cockburn Island, Graham Land, Antarctica.

2.—Tegulorhynchia coelata, (McCoy, MS.), T. Woods, sp.

(Pl. I., figs. 3, 4; pl. II., figs. 17, 20; pl. III., fig. 27.)

Rhynchonella coelata (McCoy, MS.), T. Woods, 1878, p. 77.

Rhynchonella squamosa (non Hutton), Tate, 1880, p. 32, pl. IX., figs. 9*a*, *b*.

Rhynchonella squamosa, Hutton, Denant and Kitson, 1903, p. 129.

Acanthothyris squamosa, Hutton sp. Chapman, 1914, p. 167, fig. 89F.

Description.—In his paper on the Tertiary Deposits of Australia, Tenison Woods gives a very brief description of the species which McCoy indicates as the typical Victorian form. Tenison Woods' description is as follows:—"Rounded trigonal, with a strong mesial fold, with many fine imbricated ribs." A note is added from McCoy "from several Miocene beds in Victoria."

Davidson remarks on the relationship of this to the recent form, *T. nigricans*, from New Zealand. "Some examples in external shape cannot be distinguished, but I have not observed on any recent *R. nigricans* such prominent and strongly marked imbricated striae. The fold and sinus seem more strongly marked on the fossil form. The ribs also seem smaller and more delicate than on real *nigricans*."[18]

Specific Characters.—Shell suborbicular, more or less transversely elongated. Ventral valve depressed with a deep sinus. Dorsal valve strongly convex, with a more or less flattened median fold. Umbo rounded, not prominent. Pedicle area truncated. Foramen ovate, not large. Deltidial plates triangular, with slightly vertical prolongation; slightly discrete. The area of the valves near the lateral commissure compressed. Average number of plicae on sinus, 8; on ventral, 36 to 40.

Dimensions.—Specimen *a.*—Length, 14 mm.; width, 17 mm.; thickness of valves, 9mm. Greatest width of delthyrium, 1.25.

Specimen *b.*—Another specimen (figured), length, 16 mm.; width, 18 mm.; thickness of valves, 8.5 mm.

Observations.—This Victorian rhynchonellid has long been held to be identical with the New Zealand species which Hutton described as *R. squamosa.* In various references made subsequently there have been allusions to the several points of difference between the Victorian and New Zealand specimens. From the very fine series placed at our disposal by Mr. F. A. Cudmore, which he collected at Table Cape, Tasmania, in addition to those which we have in the National Museum collection, and others recently collected by us from the ironstone beds of Green Gully, Keilor, we are enabled with some degree of certainty to refer the Victorian specimens of the type to the original species of Tenison Woods.

This species is found in the Tasmanian "*Crassatellites* bed" in company with our new species, *T. thomsoni*, of which the description follows immediately. In that description also will be found a synopsis of the characteristic differences between these two forms. As we have already shown, the shape and ornament, such as number of costae, separate *T. coelata* from Hutton's species *T. squamosa.*

Occurrence.—Oligocene. Muddy Creek, rare. Recorded by Tate.

Miocene.—Tasmania.—*Crassatellites* bed, Table Cape. South Australia.—Aldinga (Glauconitic Limestone); Muloowurtrie, near Ardros-

18. See Woods, J. E. T., 1878, p. 77.

san; Stansbury, Yorke's Peninsula; River Bremer at Salem, near Callington. Victoria.—Aire Coast; Fishing Point, Cape Otway; Lower Moorabool; Maude; Curlewis; Flinders; Waurn Ponds; Keilor.

3.—TEGULORHYNCHIA THOMSONI, sp. nov.

(Pl. I., figs. 5, 6; pl. II., figs. 18, 21; pl. III., fig. 28.)

Description.—Shell subovate, tending to subglobose in shape, slightly wider than long. Shell stout, as in *T. coelata.*. Delthyrium is large and open. Deltidial plates strong, triangular and nearly equilateral, reminding one of similar characters in *T. nigricans.* Sinus not so deep as in *T. coelata.* Surface of valves, especially the ventral, showing interrupted growth stages. Twenty-eight plicae seen on ventral valve, six on the sinus. Beak not forwardly projecting, but truncated; deltidial plates discrete.

Dimensions.—Length, 17 mm.; width, 20.5 mm.; thickness of valve, 10:25 mm. Greatest width of delthyrium, 2.5 mm.

Observations.—This species occurs in company with *T. coelata*, T. Woods, at Table Cape, and it is interesting to note that the presence of two species was also suspected by Dr. J. Allan Thomson a few years ago. In 1914, in a letter to one of us he says: "There are two species at least at Table Cape. One appears to be *H. squamosa*, and this was probably the one called *R. coelata* by McCoy. The other is coarser ribbed and less squamose, and is also, I think, represented in New Zealand, but I would like to see a larger series of specimens before making a definite statement."

The differences between the shells of the above species and *T. coelata* are easily seen when a comparative series is laid out. These differences are as follow:—

T. thomsoni.	*T. coclata.*
Beak more prominent, approaching that of *T. nigricans.*	Beak not prominent, apex rounded in edge view, not incurved.
Plicae stouter and less numerous.	More numerous.
Six plicae on sinus.	Eight plicae on sinus.
The growth-lines not conspicuous until reaching the beginning of the ephebic stage.	Tegulation and growth-lines clearly at the beginning of the neanic stage.
Convexity more evenly distributed on both valves.	Dorsal valve tends to become extremely convex, and the fold on the sinus is more pronounced.
Lateral cardinal area evenly convex.	Compression of the lateral cardinal area pronounced.
Foramen large and rounded.	Foramen oval.
Deltidial plates equilateral; discrete, but less so than in *T. coelata.*	Deltidial plates vertically lengthened; discrete.

We have much pleasure in naming this species after Dr. Thomson, who has already done so much in regard to the description of our rhynchonellids.

Occurrence.—Miocene (Janjukian):—"*Crassatellites* bed," Table Cape, Tasmania. Type from the Dennant Collection.

4.—TEGULORHYNCHIA ANTIPODA, Thomson, sp.

Hemithyris antipoda, Thomson, 1918, p. 117.

Description.—The following definition is taken from Dr. Thomson's notes, as recorded above. The shell is of the same size as *nigricans* and *squamosa*. It is distinguished primarily by the character of the ribs. They are similar in size to *H. nigricans*, but are rather more numerous, and are incipiently spinous. To this we may briefly add the above species appears to be near *T. thomsoni*, but differs in the shape of the beak, and in the stronger growth-lines.

Dimensions.—Length, 20 mm.; breadth, 22 mm.; thickness, 11 mm.

Occurrence.—Miocene. Type locality, Curiosity Shop, Rakaia River, Canterbury, New Zealand.

5.—TEGULORHYNCHIA IMBRICATA, Buckman, sp.

Hemithyris imbricata, Buckman, 1910, p. 11, pl. I., fig. 12

Description.—(Ventral valve). "Broadly pentagonal, ornamented with numerous, somewhat stout, rounded radial, costae, which are crossed by growth-lines somewhat conspicuously; and where the crossings occur there is imbrication—the test of the rib being raised into an incipiently spinous projection. The ribs increase in number by intercalation, and by bifurcation, at irregular distances from the beak. The new rib so produced is of smaller size at first than the older ones, so that there is some irregularity of ribbing. There is a distinct mesial sinus."

Observations.—Buckman draws attention to the affinities of this species, with *T. doederleini*, Davidson, sp., the living Japanese form with hollow spines. It also shows some relationship with our new species, *T. coelospina*, described below. From the latter, *T. imbricata* differs in having finer costae, more transverse shell, and a more depressed sinus on the ventral valve.

Occurrence.—Miocene. Glauconitic Bank, Cockburn Island, off Graham Land, Antarctica.

6.—TEGULORHYNCHIA, COELOSPINA, sp. nov. Pl. I., fig. 7; pl. III., fig. 25.

Description.—Shell subcircular, beak fairly prominent, erect. In the type specimen, deltidial plates obscure, but seen in other examples to be triangular and strongly built; slightly discrete. Umbo of dorsal valve acute. Shell depressed, the valves showing almost equal convexity. Sinus and fold little pronounced. Plicae about four on ventral sinus. Costae about twenty-two on margin of valves. Bufurcation of the costae takes place in the later stages. The growth-

lines are developed on the costae as incipient tubular spines, somewhat developed to a market extent. The whole surface has a roughened appearance from the numerous short but prominent spines.

Dimensions.—Length, 9 mm.; width, 10 mm. Greatest thickness of valves, 4 mm.

Observations.—This Miocene form seems suggestive in its distinctly spinous characters, of a phylogenetic relationship with the living *T. doederleini*. That Buckman's suggestion that "spinosity is in itself not a generic character, it is only a stage of development to which various stocks attain" may apply in this case, but in the case of the *squamosa* type passing into *nigricans*, this principle does not seem to apply, for *squamosa* and *coelata* have a spinous tendency, but they afterwards develop into the less ornate type of *nigricans* in which the growth-lines are sometimes scarcely perceptible.

Occurrence.—Miocene. Table Cape, Tasmania.

TEGULORHYNCHIA DEPRESSA, Thomson, sp.

Hemithyris depressa, Thomson, 1918, p. 117 (see also p. 108).

Description. (From Dr. Thomson's notes). *T. depressa* is a small species with a short beak It is broader than *T. sublaevis*, and more depressed, and possesses numerous fine ribs, and with imbrication towards the margin.

Dimensions.—Length, 14 mm.; breadth, 16 mm.; thickness, 8 mm.

Occurrence.—(?) Oligocene and Miocene. Type locality, limestone above tuffs, one mile north of Kakanui Quarry, Oamaru district.

8.—TEGULORHYNCHIA TUBULIFERA, Tate, sp. (Pl. I., fig. 8; pl. III., figs. 23, 24.).

Rhynchonella (?) *tubulifera*, Tate, 1899, p. 257, pl. VIII., figs, 4, 4*a*.

Description.—(Of the type). "Shell tenticular, suborbicular or transversely quadrate-oval in margin outline; cardinal margin arched, anterior and posterior margins rounded, front margin nearly straight. Pedunculate valve depressed convex; beak bluntly and shortly pointed, straight, and declinous from the hinge: foramen broadly triangular, large, margined by two suberect, narrow lanceolate deltidial pieces."

"The ornament of the valves consists of round radial costae, increasing in numbers by repeated bifurcation, forty or more slightly serrating the margin; there they are a little wider than the subconcave furrows. The ribs are surmounted by stout truncated tabular spines, sufficiently close together to be almost imbricated."

"*Dimensions.* Length, 7.5 mm.; height, including beak, 6.7 mm.; thickness of valves, 2.5 mm."

Observations.—The type from which the above description was taken was referred to by Tate as unique. There is, however, an imperfect specimen in the Dennant collection in the National Museum, which is, without doubt, referable to the above species with which it agrees in main characters and ornament, and differing in the slightly

less number of costae, and in the beak being a little more prominent. We have enlisted the good services of Professor Sir Douglas Mawson in endeavouring to find the original specimen, that we might examine it, but it has not come to light. As we have gone into the matter of the identity, or otherwise, of the fragment, with Tate's type, we may note that our conclusions are in favour of the probability of there being two specimens the type evidently having been perfect.' Since Tate records his type from Muddy Creek, polyzoal rock series, it is interesting to note that the Dennant specimen came also from the same bed. The differences between this form, and the previously described *T. coelospina* are in the depressed valve of the latter, and the coaser and fewer tubulated costae.

We have been favoured by Mr. Cudmore with a fragmentary valve of a rhynchonellid, presumably from the Lower beds of Muddy Creek, and this we have figured. It appears to approach most nearly *T. tubulifera*, but differs in some respects, and may point to the existence of an additional species in our series.

Occurrence.—Oligocene. (Balcombian). Lower beds, Muddy Creek. Miocene. (Janjukian). Polyzoal Rock, junction of Grange and Muddy Creek.

9.—TEGULORHYNCHIA DOEDERLEINI, Davidson, sp.

Rhynchonella doederleini, Davidson, 1886, p. 1, text-fig. 19.
Rhynchonella doederleini, Davidson, 1887, p. 172, pl. XXV., figs. 14, 15.

Description.—" Shell transversely subpentagonal, wider than long; hinge-line obtusely angular. Dorsal valve deep, posteriorly uniformly convex, anterior divided into three lobes, the central one forming a broad rounded mesial fold varying in elevation according to the age of the individual. Ventral valve much less deep than the dorsal one, with a broad mesial sinus or greater or less depth, commencing at a third of the length of the shell, and extending to the front. Beak moderately produced, almost erect, with an oval-shaped foramen situated under its gently incurved angular extremity, and margined by narrow deltidial plates. Lateral margins of the valves slightly sinuated, and forming in front a more or less elevated curve. Surface of valves marked with numerous delicate radiating ribs, with interspaces between them of almost equal width, and increasing in number at variable distances from the beaks by the interpolation of shorter riblets. Ribs numbering, in full-grown specimens, sixty, close to the margin. Valves closely crossed by numerous equidistant, concentric, raised or foliated lines of growth, giving rise at the margin of each riblet to short sloping or erect hollow spinules. Shell structure fibrous. Colour, light yellowish grey. In the interior of the dorsal valve are two short curved lamellae for the support of the labial appendages."

Dimensions.—" Length, 12 lines; breadth, 13; depth, 7 lines."

Observations.—This living species was compared in its spinosity to the Jurassic "*Rhynchonella*" *spinosa* by Davidson,[14] and was later

14. Davidson, 1886, p. 2.

referred to the Oolitic genus, *Acanthothyris*, by Schuchert.[15] It seems, however, that two distinct races, with senescent spinosity, were thus confused. Buckman[16] has remarked that *T. doederleini* is "more probably a spinous development of *Hemithyris nigricans*"; but here we may point out that, in the light of the structure of the Miocene forms, such as *T. coelospina* and *T. tubulifera*, and even of *T. imbricata*, that it is a direct descendant of the *coelospina* type rather than of the *nigricans* type.

T. doederleini has the beak and deltidial characters precisely identical with the old Miocene and even Oligocene forms, as *T. squamosa* and *T. coelata*, but the extent of development of tubuli formed out of the tegulated frilling has here resulted in long serial and regular spines. In the conjunct deltidial plates it agrees with *T. squamosa*.

Occurrence.—Dredged in 160 fathoms, in Sagami Bay, Japan.

10.—Tegulorhynchia nigricans, Sowerby, sp.

(Pl. I., figs. 9, 10, 11, 12; pl. III., figs. 29, 30.)

Rhynchonella nigricans, Sowerby, 1846, p. 91.
Rhynchonella nigricans, Suess, 1864, p. 60, pl. XIV., fig. 6.
Rhynchonella nigricans, Kirk, 1880, p. 303.
Rhynchonella nigricans, Davidson, 1887, p. 169, pl. XXIV., figs. 16-19.
Rhynchonella nigricans, Hutton, 1905, p. 480.
Hemithyris nigricans, Sow., sp., Thomson, 1915, p. 388, and p. 390, text-fig. 2*a*.

Description.—The following abbreviated description is given by Hutton.[17] "Shell thin, wider than long, but very irregular in shape; margin crenulated, commissure sinuated. Longitudinal ribs, 20 to 25 in each valve."

"*Dimensions.*—Length, 19 mm.; width, 21 mm.; thickness, 10 mm."

Observations.—This species makes its appearance in the Upper Tertiary of New Zealand (probably Upper Miocene and Pliocene), where it is represented by more massive shells than those of the recent specimens dredged around New Zealand. In the living examples the beak is usually more prominent, especially in the younger stages, and the deltidial plates are discrete. In the fossil forms the plates are more closely approximate.

Thomson considers the probability that this species "is a catagenetic development of a coarsely ribbed, imbricated, Oamaruian (probably Miocene), species are not yet named, which differs from *H. squamosa* in its much coarser ribs." This view of Thomson's is upheld by the evidence of the series now before us, *T. thomsoni* helping to connect the extremities of that series.

Occurrence.—Miocene to Recent. New Zealand.

15. Schuchert (Zittel), 1913, p. 400.
16. Buckman, 1910, p. 11.
17. Hutton, 1905, p. 480.

11.—TEGULORHYNCHIA PYXIDATA, Davidson, sp.

Rhynchonella nigricans, var. *pyxidata*, Davidson, 1880, p. 59, pl. IV., fig. 14.

Rhynchonella nigricans, var. *pyxidata*, R. B. Watson (MS.), Davidson, 1887, p. 170, pl. XXIV., fig. 20.

Hemithyris pyxidata, Davidson, sp. Thomson, 1915, p.391, footnote 4.

Description.—(From Davidson). "Shell transversely oval, widest anteriorly, tapering posteriorly, wider than long. Dorsal valve uniformly convex to about half its length, where a broad mesial fold, scarcely raised above the general convexity of the valve, occupies the anterior half of the valve. Ventral valve rather less deep and convex than the opposite one, with a broad, well-defined mesial sinus, comencing at a short distance from the extremity of the beak, and extending to the front; beak rather small, acute, and incurved; foramen incomplete, situated under its pointed extremity, laterally margined by narrow deltidial plates; surface of both valves ornamented with about forty to forty-six small, angular, radiating ribs, closely intersected by equidistant, squamose, concentric ridges of growth, giving an imbricated appearance to the surface. Colour whitish, sometimes brownish, especally at the beaks."

"*Dimensions.*—Length, 9 lines, breadth 10 lines, depth 6 lines."

Observations.—Davidson states that, "After careful study and comparison with an extensive series of New Zealand types, I am led to the conclusion that *Rhynchonella pyxidata* is merely a local variety of *R. nigricans*." From the present standpoint, after an examination of many other variants of this series, which for convenience are given specific rank, we are inclined to regard *T. pyxidata* as distinct, on the grounds of having a more incurved beak, a less subtrigonal outline, whilst the costation is much finer and the ribs are more distinctly burfurcated towards the anterior commissure. Davidson also remarks that *T. pyxidata* "seems absolutely undistinguishable" from McCoy's "*Rhynchonella*" *coelata* from Table Cape. The Table Cape species, however, appears to have a less acute beak, which is not so strongly incurved; the shell is more elongated transversely, and the tegulation is always well developed, whereas in *T. pyxidata* the growth-lines are is an incipient stage.

In a communication recently received, Dr. Thomson strongly confirms our idea of the specific distinction of *T. pyxidata*. He also points out that the New Zealand *squamosa* has conjunct deltidial plates, whereas in *pyxidata* they are discrete.

Occurrence.—Recent. Dredged by the "Challenger," south of Kerguelen Islands, at a depth of 150 fathoms.

12.—TEGULORHYNCHIA SUBLAEVIS, Thomson, sp.

Hemithyris sublaevis, Thomson, 1918, p. 117, see also p. 108.

Description.—A small species with a short beak, narrowly and strongly folded, with numerous fine ribs, little imbricated and in many specimens almost obsolete. (From Dr. Thomson's notes.).

Dimensions.—Length, 10 mm.; breadth, 10.5 mm.; thickness, 7 mm.

Occurrence.—(?) Oligocene. Type locality, Everett's Limestone Quarry, Kakanui, Oamaru District.

Acknowledgments.

In the preparation of this paper we desire to express our great obligations to Dr. Allan Thomson, M.A., Director of the Dominion Museum, Wellington, who has sent us on loan a most representative collection of New Zealand fossil rhynchonellids, and has presented the topotype of Hutton's *T. squamosa* to the National Museum. In addition he has taken a lively interest in our work, and we have had from him many valuable suggestions.

Our acknowledgements are also due to Mr. J. A. Kershaw, F.E.S., Curator of the National Museum, for kindly supplying us with the recent examples of *Hemithyris psittacea* and *T. nigricans*, from the zoological collections.

To Mr. F. A. Cudmore our best thanks are due for his kindness in placing in our hands the whole of his fine collection of rhynchonellids, for use in descriptive work; and for donating the specimens we have figured, to the National Museum collection.

We have also made use of a topotype of *T. squamosa* kindly sent by Mr. P. Morgan, Director of the Geological Survey of New Zealand, who has also supplied localities of New Zealand specimens in the National Museum, and to him our thanks are due.

We express our best thanks to Mr. F. A. Singleton, M.Sc., for bringing under our notice several references.

To. Mr. H. Finlay we are indebted for a collection of rhynchonellids from Target Gully, New Zealand, which has been useful in our descriptive work.

V.—Summary.

1.—The austral forms of the "*nigricans* series," to which we give the new generic term, *Tegulorhynchia*, constitute a zoological group distinct from the boreal generic type, *Hemithyris*.

2.—The examination of the more spinous members of the genus *Tegulorhynchia*, including *T. coelospina* and *T. doederleini*, confirms the assumption that they have no relationship with the spinous genus, *Acanthothyris*, D'Orbigny, of Jurassic age, but are variants, not necessarily senescent, in which the tegulation is carried to an extreme in the form of redundant ornament.

3.—From an examination of the Australian Mesozoic rhynchonellid fauna, it is postulated that, the Cainozoic species of the *Tegulorhynchia* series have probably evolved from a Jurassic form like that of *Burmirhynchia*, Buckman, and without the intervention of the *Cyclothyris* type, which seems to have been entirely confined to the Cretaceous of Europe.

4.—The particular form which appears to be in the direct line of descent, and which is of Australian occurrence, is the well-known European type, "*Rhynchonella*" *variabilis*, Schlotheim, sp.

5.—The majority of form of *Tegulorhynchia* point to the fact that they were mainly inhabitants of shallow to moderately deep water, probably ranging from shore-line to several hundred fathoms.

6.—Twelve species are here arranged under the genus *Tegulorhynchia*, of which two are new, namely, *T. coelospina* and *T. thomsoni*.

7.—Our present knowledge of the distribution of the genus, both living and fossil, includes Patagonia, Brazil, Antarctica, Kerguelen Island, New Zealand, Victoria, Tasmania and South Australia.

8.—The doubtful record, as an Australian fossil, of "*Rhynchonella baileyana*" has been examined in the light of the figured specimen, and it is here definitely referred to the European species, *Cyclothyris limbata*, Schlotheim, sp.

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VII.—EXPLANATION OF PLATES.

PLATE XI.

Fig. 1.—*Tegulorhynchia squamosa*, Hutton, sp. Dorsal view of the topotype. Trelissick, Basin, New Zealand. Miocene (Oamaruian). Coll. Dr. J. A. Thomson. Circ., 2 diameters.

„ 2.—*T. squamosa*, Hutton, sp. Ventral view of fig. 1. Circ., 2 diameters.

„ *T. coelata*, T. Woods, sp. Dorsal view. Waurn Ponds, near Geelong. Miocene (Janjukian). Dennant coll. Neotype, from a similar horizon to T. Woods' specimen, but from different locality. Circ., nat. size.

„ 4.—*T. coelata*, T. Woods, sp. Ventral view of fig. 3. Circ., nat. size.

„ 5.—*T. thomsoni*, sp. nov. Ventral view. Table Cape, Tasmania. Miocene (Janjukian), Crassatellites Bed. Dennant coll. Circ., nat. size.

„ 6.—*T. thomsoni*, sp. nov. Dorsal view of fig. 5. Circ., nat. size.

„ 7.—*T. coelospina*, sp. nov. Dorsal view. Table Cape, Tasmania. Miocene (Janjukian). Crassatellites Bed. Dennant coll. Circ., 2 diameters.

„ 8.—*T. tubulifera*, Tate, sp. Part of Dorsal valve. Polyzoal Limestone, junction of Grange Burn, Muddy Creek. Miocene (Janjukian). Dennant coll. Circ. 2 diameters.

„ 9.—*T. nigricans*, Sowerby, sp. Dorsal view. Trelissick Basin, New Zealand. Awamoan (Upper Miocene). Von Haast coll., Nat. Mus. Circ., nat. size.

„ 10.—*T. nigricans*, Sow., sp. Dorsal view. New Zealand. Recent. Nat. Mus. coll. Circ., nat. size.

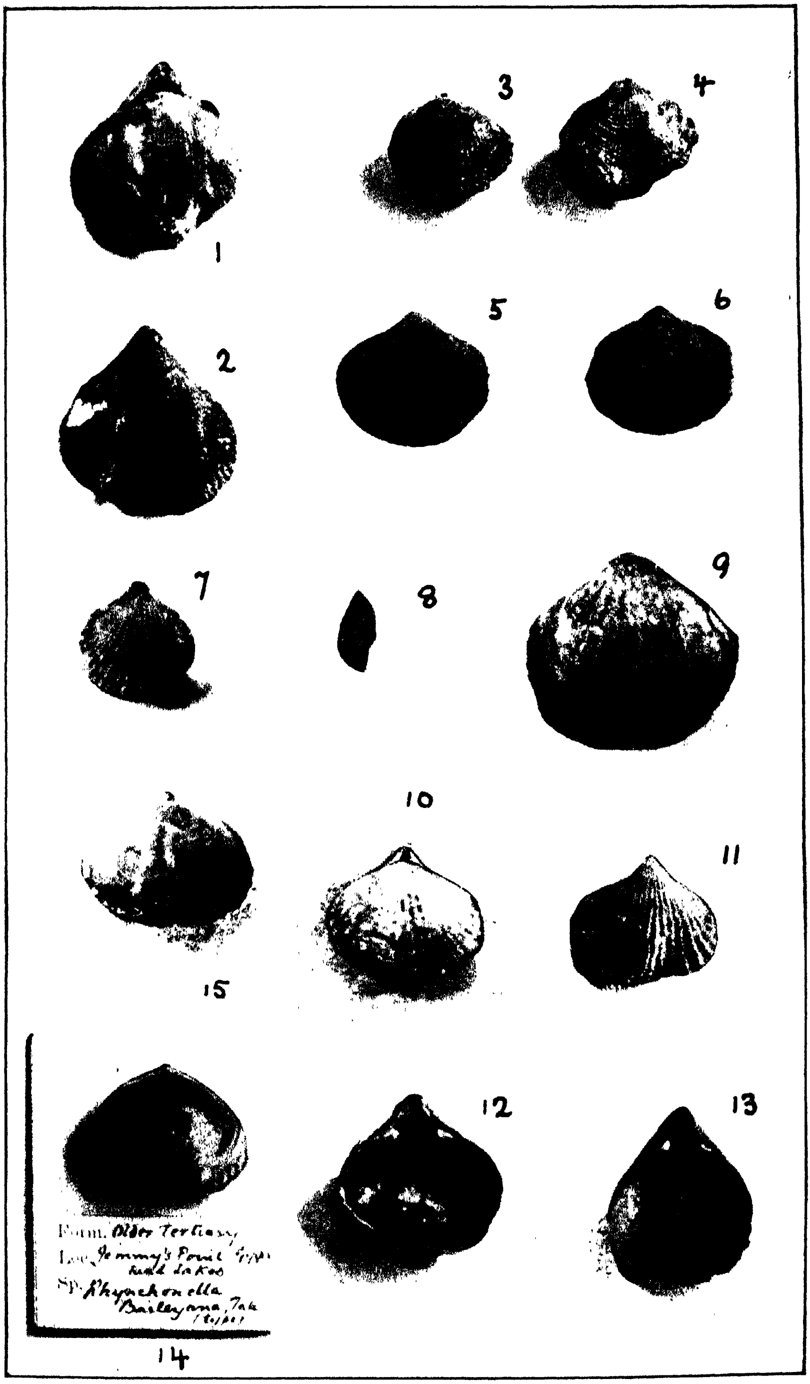
„ 11.—*T. nigricans*, Sow., sp. Ventral view of fig. 10. Circ., nat. size.

„ 12.—*T. nigricans*, Sow., sp. Internal view of ventral valve, showing dental plates. New Zealand. Recent. Nat. Mus. coll. Circ., nat. size.

„ 13.—*Hemithyris psittacea*, Chemnitz, sp. Internal view of ventral valve, showing dental plates. Northern Seas. Recent. Nat. Mus. coll. Circ., nat. size.

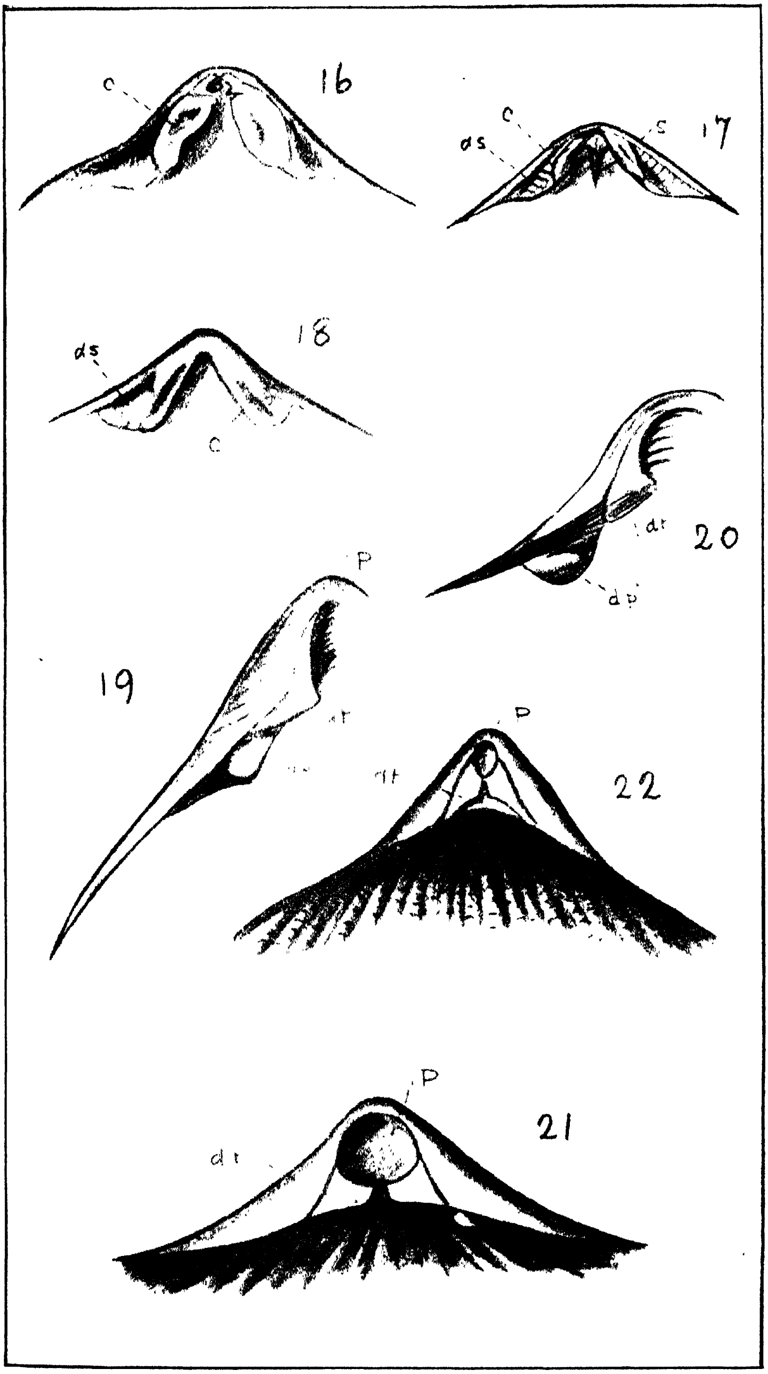
„ 14.—"*Rhynchonella baileyana*," Tate. Dorsal view of Tate's type specimen. The supposed fossil from Jemmy's Point, Gippsland Lakes. = *Cyclothyris limbata*, Schlotheim, sp. The figured specimen from the Adelaide Museum. Circ., nat. size.

„ 15.—*Cyclothyris limbata*, Schlotheim, sp. Dorsal view. Ciply, Belgium. Upper Cretaceous (Senonian). Nat. Mus. coll. Circ., nat. size. Typical example for comparison with Tate's *R. baileyana*.



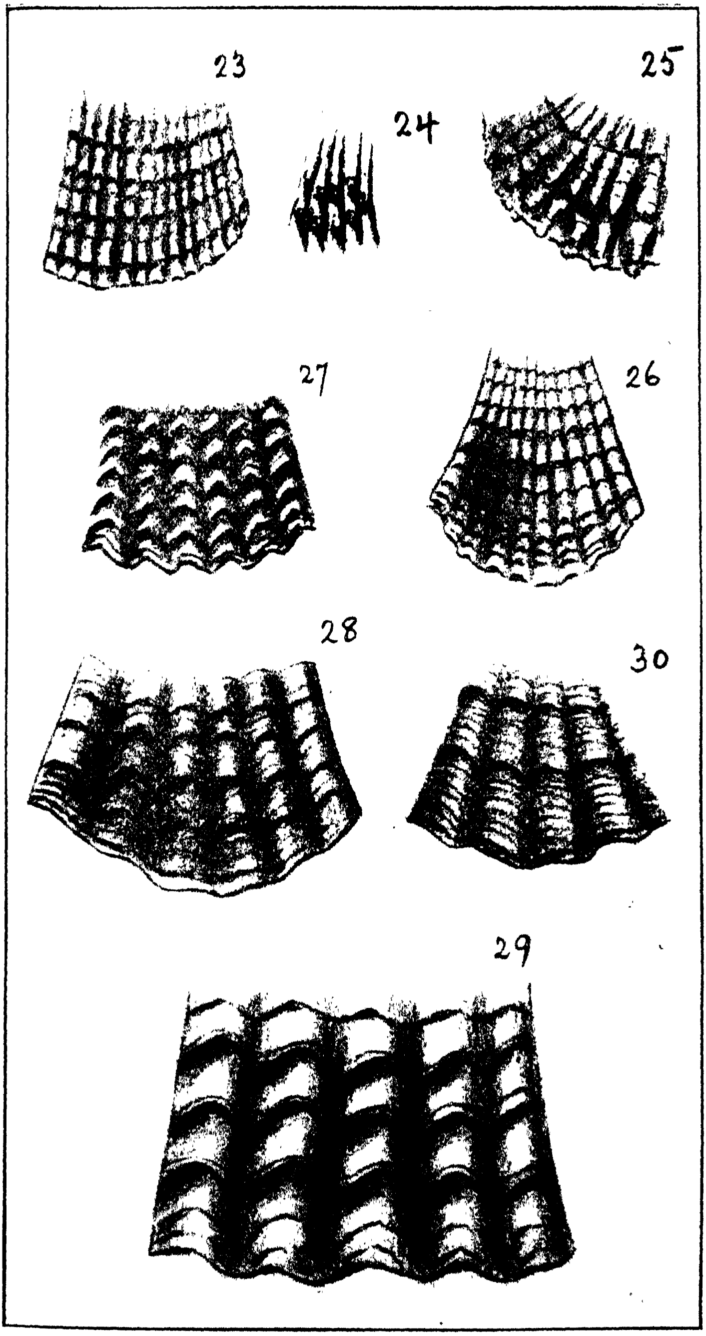
F. C. Photo

Rhynchonellids: Cretaceous, Cainozoic and Recent



I.C. et F.C. ad nat. del.

Crura and Deltidia of Rhynchonellids × 5 diam.



I.C. et F.C. ad nat. del.

Surface Ornament in Tegulorhynchia, gen. nov.

Plate XII.

All figures on this plate enlarged five times.

Fig. 16.—Crura of *Hemithyris psittacea*, Chemnitz, sp. North Seas. Recent.

,, 17.—Crura of *Tegulorhynchia coelata*, T. Woods, sp. Table Cape, Tasmania. Miocene (Janjukian). F. A. Cudmore coll.

,, 18.—Crura of *T. thomsoni*, sp. nov. Table Cape, Tasmania, Miocene (Janjukian). F. A. Cudmore coll.

,, 19.—Dental plate of *Hemithyris psittacea*, Chemn., sp. North Seas. Recent.

,, 20.—Dental plate of *Tegulorhynchia coelata*, T. Woods, sp. Table cape, Tasmania. Miocene (Janjukian). Dennant coll.

,, 21.—Pedicle aspect of *T. thomsoni*, sp. nov. Table Cape, Tasmania. Miocene (Janjukian). F. A. Cudmore coll.

,, 22.—Pedicle aspect of *T. squamosa*, Hutton, sp. New Zealand, Ototaran. J. A. Thomson, coll.

Legend.—P., pedicle passage; c., crural lobes; d.s., dental sockets; dt., deltidial plates; dp., dental plates; s., septum.

Plate XIII.

Surface Ornament.—All figures on this plate enlarged five times.

Fig. 23.—*Tegulorhynchia* (?) *tubulifera*, Tate, sp. From the dorsal valve. Muddy Creek. Oligocene (Balcombian). F. A. Cudmore coll.

,, 24.—*T. tubulifera*, Tate, sp. From side of ventral valve. Grange Burn, Muddy Creek. Miocene (Janjukian). Dennant coll.

,, 25.—*T. coelospina*, sp. nov. From side of ventral valve. Table Cape, Tasmania. Miocene (Janjukian). Dennant coll.

,, 26.—*T. squamosa*, Hutton, sp. From sinus of ventral valve. Trelissic, New Zealand. Ototaran. J. A. Thomson coll.

,, 27.—*T. coelata*, T. Woods, sp. nov. From sinus of ventral valve. Waurn Ponds, near Geelong. Miocene (Janjukian). Dennant coll.

,, 28.—*T. thomsoni*, sp. nov. From sinus of ventral valve. Table Cape, Tasmania. Miocene (Janjukian). F. A. Cudmore, coll.

,, 29.—*T. nigricans*, Sowerby, sp. From sinus of ventral valve, Amuri District, North Canterbury. Tertiary (?Up. Miocene). Von Haast coll., in Nat. Mus.

,, 30.—*T. nigricans*, Sow., sp. From sinus of ventral valve. New Zealand. Recent. Dredged.

[PROC. ROY. SOC. VICTORIA, 35 (N.S.), PT. II., 1923.]

ART. XIX.—*Contributions from the National Herbarium of Victoria, No. 3.**

BY J. R. TOVEY and P. F. MORRIS.

[Read 14th December, 1922.]

The present paper contains, (1) a description of a new species of Kunzea from West Australia, *Kunzea sulphurea;* (2) records of new regional distribution of native and introduced plants; (3) a new introduction in Victoria; (4) alterations in the botanical nomenclature of plants in accordance with article 48 of the (*Rules of the*) Vienna Botanical Congress (1905); (5) additions to the Introduced Flora of Coode Island, in which six exotic plants have been recorded for the first time.

KUNZEA SULPHUREA, sp. nov.

Frutex ramosus 5m. altus; foliis oblongis-cuneatis 3-4 mm. longis, 1-1.5mm. latis; bracteis 3mm. longis, 2-2.5mm. latis; bracteolis angustioribus. Petalis sulphureis.

A tall, almost arborescent, glabrous shrub up to 18 feet high. Leaves alternate, very shortly petiolate, 3-4 mm. long, 1-1.5mm. broad, oblong-cuneate, obtuse or slightly acuminate, flat, erect or slightly recurved, imbricate on the younger branchlets. Flowers glabrous, sessile, about 20 in a terminal globular head—the branches growing through after flowering; the rhachis pubescent. Bracts ovate, boat shaped, scarious, 3 mm. long, 2 mm. broad, veins plainly visible. Bracteoles narrower. Calyx tube 3-4mm. long, ovoid, glabrous sometimes ridged at the base, oil dots conspicuous; lobes small, ⅓ length of petals, ovate, obtuse. Petals yellow, about ½ the size of the calyx tube. Stamens about 30, nearly 3 times as long as the petals. Ovary 5-celled, about 6 ovules in each cell. Seeds black, oblong. Immature capsule, 3-4 mm. diameter.

Habitat.—Big Brook, Warren District, Western Australia, Max Koch, No. 2539, Nov. 1920.

Placed in the section *Eukunzea* near *K. micrantha.*

CRASSULA EXSERTA (READER) Ostenf. (*Crassulaceae*).

Flinders Island, Tasmania, Dr. C. S. Sutton, Nov., 1912.

This plant was previously recorded from Victoria only.

STATICE THOUINI, Viv. "Thouin's Sea Lavender," (Plumbaginaceae).

Mt. Wycheproof, Rev. W. W. Watts, Nov. 1916; Birchip, Oct., 1918; Ouyen, Mr. McGregor, October, 1922.

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*No. 2 in the Proc. Roy. Soc. Vic., Vol. 35, pt. I.

This plant, which was recorded as a garden escape in Proc. Roy. Soc. Vict. XXX. (1918), has now evidently established itself as a naturalized alien in the north-western districts of Victoria.

Bromus Cebadilla, Steud. "Chillian Brome Grass." (*Gramineae*).

Ovens Vale, Victoria, H. M. Campbell; June, 1922.

A new locality in Victoria for this introduced grass. It has a fair pasture value, but is not in the first rank of fodder plants.

Tradescantia fluminensis, Vell. "Water Spiderwort." (Commelinaceae).

Sandringham, Victoria, A. J. Tadgell, Oct., 1922.

This plant, a native of Brazil, may be classed as an exotic not yet sufficiently established to be considered naturalised.

The following, collected at Wattville by Mr. O. B. O'Dowd, have not been previously recorded from the north-eastern districts of Victoria:—*Craspedia chrysantha*, Benth.; *Eritrichium australasicum*, A.D.C.; *Eutaxia empetrifolia*, Schlech.; *Helipterum Jesseni*, F.v.M.; *Myriocephalus rhizocephalus*, Benth.; *Panicum prolutum*, F.v.M.

Alterations in accordance with Article 48 of the Vienna Botanical Congress (1905).

Cladium acutum, (Lab.) Poir., syn. (*Cladium schoenoides*, *R. Br.*, *Schoenus acutus*, Lab). (*Cyperaceae*).

Cladium capillaceum, C. B. Clark., syn. (*Elynanthus capillaceus*, Benth., *Schoenus capillaris*, F.v.M.), *Cyperaceae*.)

Cladium tetragonum, (Lab.), J. M. Black., syn. (Lepidosperma *tetragona*, Lab., *Cladium tetraquetrum*, Hook, f.). (*Cyperaceae*).

Distichlis spicata (L.), Greene., syn. (*Uniola spicata*, L., *Distichlis maritima*, *Rafin.*).

Helichrysum cuneifolium, (D.C.), comb., nov. (*Cassinia cuneifolia*, D.C., (1837)). (*Ozothamnus Backhousii*, Hook, f., (1860). (*Helichrysum Backhousii*, F.v.M., (1866), (*Compositae*).

De Candolle's original specific name has priority over that of Mueller's. A native of Victoria and Tasmania.

Helichrysum lepidophyllum (D.C.), comb., nov. (*Baccharis lepidophylla*, D.C., (1837), *Ozothamnus lepidophyllus*, Hook, f., (1847); *Helichrysum baccharoides*, F.v.M., (1886). (*Compositae*).

De Candolle's original specific name has priority over that of Mueller's. A native of Victoria, New South Wales and Tasmania.

Helichrysum oblongifolium, comb., nov. (*Helichrysum cuneifolia*, F.v.M., (1866)). (*Compositae*).

As we have already a *H. cuneifolium* (*Cassinia cuneifolia*, D.C., (1837)), we have given this plant the name of *H. oblongifolium*. It is a native of Victoria and New South Wales.

HELICHRYSUM STEETZIANUM, comb., nov. (*Helichrysum lepidophyllum* F.v.M., (1866); *Ozothamnus lepidophyllus*, Steetz., (1844-5)). (Compositae).

As we have already a *H. lepidophyllum* (*Baccharis lepidophylla*, D.C., (1837)), we have given the name of *H. Steetzianum* to this plant, It is endemic to Western Australia.

IMPERATA CYLINDRICA, (L.), Beauv. (*Lagurus cylindricus*, L., *Imperata arundinacea*, Cyr.). (*Gramineae*).

POA DRUMMONDI, Nees. (*Poa nodosa*, Nees); (*Gramineae*).

SCIRPUS AMERICANUS, Pers. (*S. pungens*, Vahl); (*Cyperaceae*).

SCIRPUS ANTARCTICUS, L. (*S. cartilagineus*, Poir.; *Isolepis cartilaginea*, R. Br.); (*Cyperaceae*).

ADDITIONS TO THE INTRODUCED FLORA OF COODE ISLAND.

The following specimens were collected at Coode Island, Victoria, and as they did not agree exactly with the material in our Herbarium, they were submitted to the Director of the Royal Botanic Gardens, Kew, England, for comparison with the material in the Kew Herbarium. The specimens were there identified as follow:—

AGATHOSMA APICULATA, E. Mey. (Rutaceae). J. R. Tovey, Nov. 1912.

ANTHERICUM LONGIFOLIUM, Jacq. (Liliaceae). J. R. Tovey, Nov, 1912.

CAPNOPHYLLUM AFRICANUM, Koch. (*Umbelliferae*). J. R. Tovey and C. French, jnr., March 1912; Geelong Foreshore. H. B. Williamson, (No. 1270), November, 1906.

PASSERINA FILIFORMIS, L. (*Thymelaeaceae*); J. R. Tovey and C. French, jnr., October, 1908.

PHACELIA TANACETIFOLIA, Benth. (*Hydrophyllaceae*). J. R. Tovey, Nov., 1908.

SUTERA FLORIBUNDA, O'Ktze. (*Scrophulariaceae*). J. R. Tovey, Dec., 1908.

They are all natives of South Africa, with the exception of *Phacelia tanacetifolia*, Benth., which is a native of California. All may be classed as exotics not yet sufficiently established to be considered naturalised.

TRICHINIUM OBOVATUM, Gaud., var. GRANDIFLORUM, Benth.; syn. (*Trichinium incanum*, R. Br., var. *intermedium*, Ewart and White); (*Amarantaceae*).

Warrana, South Australia. (Elder Exploring Expedition) R. Helms, May, 1891.

T. incanum, var. *intermedium* was described in the Proc. Roy. Soc. Vic., Vol. 22, p. 97 (1909), as a new variety. The plant has the broad glabrous (or nearly so) bracts, the longer perianth and the ovary slightly hairy on the top, as in *T. obovatum*, and as it agrees in other respects with the variety *grandiflorum*, Benth., of *T. obovatum*, Gaud., it must be transferred to that variety.

ANNUAL REPORT OF THE COUNCIL.

For the Year 1922.

The Council herewith presents to Members of the Society the Annual Report and Statement of Receipts and Expenditure for the past year.

The following meetings were held:—

March 9th.—Annual Meeting.

The following Office-bearers retired by effluxion of time:—President, Professor Ewart; Vice-Presidents, F. Wisewould, Professor Laby; Hon. Treasurer, W. A. Hartnell; Hon. Librarian, A. S. Kenyon; Hon. Secretary, J. A. Kershaw; Members of Council, Professor Skeats, Professor Agar, Dr. Green, Messrs. Chapman, Herman, Shepherd.

The following were elected:—

President, F. Wisewould; Vice-Presidents, Professor Laby, Dr. Baldwin; Hon. Treasurer, E. Kidson; Hon. Librarian, A. S. Kenyon; Hon. Secretary, J. A. Kershaw; Members of Council, Professor Skeats, Professor Agar, Dr. Green, Messrs. Chapman, Herman, Shepherd, Gray.

The Annual Report of the Council, and Financial Statement were read and adopted.

At the close of the Annual Meeting, an ordinary meeting was held. Exhibits: Professor E. W. Skeats showed glacial and other rocks from Mt. Kosciusko, and gave a detailed account of their occurrence. Mr. F. Chapman showed an example of Callus in wood of the Grey Box, probably induced by a fungus, and some remarkable Sea Urchins recently added to the fossil collection of the National Museum. Professor W. A. Osborne showed and described tests for Colour Blindness. Professor T. H. Laby exhibited Double Thermo-couple for determining Recalescence Temperature of Metals. Mr. R. T. Patton showed examples of structure of wood of Moreton Bay Fig.

Mr. George Lancelot Thirkell, B.Sc., and Mr. John Lloyd Strevens were elected Members.

April 20th.—Papers: (1) "New or Little-known Fossils in the National Museum, Part 26. Some Tertiary Mollusca." By F. Chapman, A.L.S. (2) "On Coprosma Baueri, End." By John Shirley, D.Sc., and C. A. Lambert. (3) "Description of a New Victorian Helichrysum." By H. B. Williamson. (4) "Notes on Some Australian Asilidæ (Diptera) in the National Museum." By G. H. Hardy. (5) "Studies in Australian Lepidoptera." By A. Jefferis Turner, M.D., F.E.S.

Mr. Leslie R. Brookes, B.A., and Mr. P. F. Morris were elected Associates.

May 11th.—Lecture: Captain G. H. Pitt-Rivers delivered a lecture on "A Study in Social Anthropology in an Island of the Bismarck Archipelago." The lecture was illustrated by an excellent series of lantern slides, and a large number of native implements and other objects, and was followed by a discussion.

Mr. W. A. Watt was elected a Member, Dr. A. Jefferis Turner a country Member, and Messrs. R. B. Pretty and H. M. Treloar Associates.

June 8th.—Papers: (1) "On the Drying of Timber." By Reuben T. Patton, B.Sc., M.F. (2) "Contributions from the National Herbarium of Victoria." No. 2. By J. R. Tovey, and P. F. Morris.

Miss K. A. Gilman Jones, Dr. H. Flecker and Mr. J. B. Hosking were elected Associates.

July 13th.—Papers: (1) "Gravity Determinations in Australia." By E. F. J. Love, M.A., D.Sc., F.R.A.S. (2) "Revision of the Genus Pultenaea." Part III. By H. B. Williamson, F.L.S. (3) "Two New Species of Bryozoa." By W. M. Bale, F.R.M.S. Lecture: Mr. C. J. Merfield delivered a lecture on "The Total Solar Eclipse of September, 1922." The lecture was well illustrated by lantern slides.

Miss Leslie Ruth Kerr and Mrs. G. R. Thompson, were elected Associates.

August 10th.—Papers: (1) "The Occipital Bones of the Dipnoi." By Harley S. Baird, B.Sc. (Communicated by Professor W. E. Agar). (2) "New Australian Coleoptera, with notes on some previously described species." Part II. By T. Erasmus Wilson. (3) "The Relationship between Dacite and Granodiorite in Victoria." By H. Summers, D.Sc. Exhibits: Mr. D. J. Mahony showed Geological Specimens from the Kimberley District, West Australia. Dr. G. Horne exhibited some Aboriginal Feather Head Ornaments from Lake Eyre District, South Australia. Mr. Ernest Edward Trinder was elected a Member and Miss M. Cousins, and Messrs. John Strickland, R. G. Thomas, B.Ag.Sc., and C. Oke, Associates.

September 14th.—Paper: "Aboriginal Cylindro-Conical Stones." By George Horne, M.D. Lecture: Professor Orme Masson delivered a lecture on "The Structure of the Atom in its Chemical Aspect."

October 12th.—Lecture: Mr. H. Herman delivered a lecture on "Brown Coal." The lecture was illustrated by an interesting series of lantern slides. Exhibit: Dr. Baldwin showed photographs of the Total Solar Eclipse taken by the Melbourne Observatory Eclipse Party at Goondiwindi, Queensland, on September 21, 1922.

Mr. Joseph Dunstan and Mr. Alan Showers were elected Associates.

November 9th.—Papers: (1) "The Increasing Run-off from the Avoca River Basin." By E. T. Quayle, B.A. (2) "Additions to Australian Ascomycetes." No. I. By Ethel McLennan, D.Sc., and Isabel C. Cookson, B.Sc. (3) "The Specific Identity of Bacillus parabotulinus." By H. R. Seddon, D.V.Sc. (Communicated by Professor H. A.

Woodruff). (4) "The High Frequency K Series Absorption Spectra of Erbium." By L. H. Martin, B.Sc. (Communicated by Professor T. H. Laby). Exhibits: Mr. F. Chapman showed a copy of a pre-Linnean work on Shells from the shore of Arimini, written by Janus Plancus (Giovanni Bianchi) and published in 1739. The signature of Janus Plancus on the fly-leaf is interesting as, according to British Museum authorities, there is no other known. Mr. E. J. Dunn showed specimens of Maldovites from Bohemia, and Billitonites from Dutch East Indies.

Messrs W. Baragwanath, S. F. Mann, and E. G. Austin were elected Members.

December 14th.—Messrs. J. E. Gilbert and A. E. V. Richardson, M.A., B.Sc., were elected Honorary Auditors. Papers: (1) "The Austral Rhynchonellacea of the Nigricans Series, with description of the new genus Tegulorhynchia." By F. Chapman, A.L.S., and Irene Crespin, B.A. (2) "Contributions from the National Herbarium of Victoria." No. III. By J. R. Tovey, and P. F. Morris. Exhibits: Professor Skeats showed examples of Varves from the Upper Carboniferous of New South Wales, and Lower Cambrian of South Australia. Mr. R. T. Patton, B.Sc., M.F., formerly an associate, was elected a Member.

During the year eight members, one country member, and fifteen associates were elected, including one associate elected as a member. Ten members, five country members, and fourteen associates resigned, and two members and one associate died.

It is with much regret the Council has to record the losses, by death, of Mr. William A. Hartnell, Mr. A. J. Higgin, F.I.C., and Mr. William Stickland.

Alfred James Higgin, F.I.C., was born in Manchester, and trained at Owen's College, and at Zurich. He came to Ballarat over 30 years ago as Lecturer at the Ballarat School of Mines, and later was appointed Lecturer in Metallurgy at the Adelaide School of Mines, and Demonstrator in Chemistry at the Adelaide University. About 1911 he was appointed Lecturer in Metallurgy at the University of Melbourne. Mr. Higgin was a skilled metallurgist and chemist, and many of the present mining men of Australia received their training under him. His published work includes many papers on organic and inorganic chemistry, and during the war he furnished a valuable report on the manufacture of alloys for use in special stunts. He died in London on July 18, 1922.

Mr. Hartnell joined the Society in 1900, and for thirteen years occupied the position of Hon. Treasurer. In 1921, owing to continued ill-health, he was compelled to relinquish the duties of the position, which he had carried out in a particularly conscientious manner. He took a very keen interest in the work of the Society, and occupied the chair on several occasions. He died on June 21, last, in his 69th year.

Mr. William Stickland was for many years Assistant-Secretary to the Society, during which his valued assistance and uniform courtesy won for him the respect and esteem of the Council and members generally. In 1914, on resigning his position, he became an associate, and kept up his interest in the work of the Society.

The attendance at the Council meetings were as follows:—Mr. Wisewould, 10; Mr. Chapman, 10; Professor Skeats, 9; Mr. Kershaw, 9; Assoc. Professor Summers, 8; Mr. Richardson, 7; Mr. Kidson, 7; Dr. Green, 6; Mr. Picken, 6; Mr. Gray, 6; Mr. Dunn, 6; Mr. Kenyon, 6; Professor Laby, 4; Professor Agar, 4; *Dr. Baldwin, 4; Mr. Herman, 4; *Professor Osborne, 2; *Mr. Shepherd, 1.

The attendances at the ordinary meetings during the year continued satisfactory, and the interest in the work of the Society has been maintained. The continuance of the short, popular lectures on subjects of general interest has been justified by the large attendances. Four of these lectures were delivered during the year by Captain G. H. Pitt-Rivers, Mr. C. J. Merfield, Professor Orme Masson, and Mr. H. Herman.

An important event during the year was the visit to Melbourne of the Wallal Solar Eclipse Party of Astronomers. This Society cooperated with the Melbourne University in arranging a welcome. A reception was held in the Club House at the University on Wednesday, August 9, by the Chancellor of the University, and the President of this Society, and a lecture on the 1922 Solar Eclipse, by Dr. Campbell, Director of the Lick Observatory, was delivered in the Melba Hall. Both of these functions were largely attended.

The Australasian Association for the Advancement of Science held its meeting at Wellington, New Zealand, on January 11.

The Hon. Librarian reports that 2167 volumes and parts were added to the Library during the year. The Assistant-Librarian continued the work of revising the card catalogue, which is now up-to-date. The matter of shelf space for additions is giving some concern, as many publications, which should be placed in the general library, have had to be placed in the store room. Owing to lack of funds no binding was undertaken.

Part II. of Volume XXXIV. of the Proceedings was issued on May 31, and Part I. of Volume XXXV. on December 7. Part II. of this volume is now in the printer's hands, and will be available at an early date.

Mr. P. F. Morris was appointed Hon. Assistant-Treasurer, and has rendered valuable service.

The financial question has caused the Council much concern, owing chiefly to the continued high cost of printing, and to some extent to the heavy charges for postage. The drain on the Society's limited resources has been serious, and necessitated some restriction in both

* Absent on leave.

printing matter and illustrations. With a view to a reduction in the cost of publishing the Proceedings, a sub-committee was appointed to enquire into the matter, with the result that it was decided to adopt a smaller type. This, while maintaining the general standard of the publication, enabled a substantial saving of approximately £50 to be made on each volume.

The fence behind the caretaker's cottage, which had become greatly dilapidated, was replaced at a cost of £32.

Financial Statement for the year ending 28th February, 1923.

RECEIPTS.

Balance at 1st March, 1922		£31 7 10
Subscriptions—		
Members—Subs. in arrears	£37 16 0	
„ for 1922	132 6 0	
„ for 1923	6 6 0	
Associates—		
Subs. in arrears	38 17 0	
„ for 1922	69 6 0	
„ for 1923	2 2 0	
Country Members—		
Subs. in arrears	5 5 0	
„ for 1922	14 14 0	
„ for 1928	2 2 0	
		308 14 0
Rents—		
Com'wealth Government	£75 0 0	
Field Naturalists' Club...	12 0 0	
		87 0 0
Sales of Publications		5 17 6
Victorian State Government Grant in Aid		100 0 0
Donation		2 0 0
Withdrawn from Building Fund in Savings Bank		189 0 2
Exchange on Cheques		0 8 0
		£724 7 6

EXPENDITURE.

Publication, Printing and Postage—		
Printing and Publication	£325 15 7	
Postage	32 3 0	
		£357 18 7
Maintenance—		
Assistant Secretary ...	£30 0 0	
Assistant Librarian ...	12 0 0	
Caretaker's A/cs. ...	18 19 7	
Rates	14 15 8	
Insurance	5 1 3	
Sundries — Gas, Electric Light, etc.	7 7 9	
Repairs	32 13 0	
Petty Cash	4 15 1	
		125 12 4
Lantern for Lectures	3 18 0	
Collector's Commission and Expenses	14 10 10	
Library	5 16 0	
		507 15 9
Petty Cash in Hand		3 1 11
Balance in Bank		213 9 10
		£724 7 6

We have examined Pass Books and hereby certify that all amounts entered herein have been paid to the credit of the Society. We have seen receipts for all payments.

EDWARD KIDSON, *Hon. Treas.*

JAMES E. GILBERT, } *Hon.*
A. E. V. RICHARDSON, } *Auditors.*

Balance of Building Fund in Savings Bank on July 1st, 1922		£144 18 8
Subscriptions still in arrears—		
Members (3)	£6 6 0	
Associates (19)	30 9 0	
		36 15 0

Since completion of above balance, Messrs. Ford & Son's account for Vol. XXXV., Part 1, has been received, and amounts to £132/7/0.

Part 2 of the same volume is estimated to cost £160.

Royal Society of Victoria.

1922.

Patron:

HIS EXCELLENCY THE RIGHT HON. THE EARL OF STRADBROKE, K.C.M.G. C.B., C.V.O., C.B.E.

President:

F. WISEWOULD.

Vice-Presidents:

PROF. T. H. LABY, M.A., Sc.D., F.INST.P.
J. M. BALDWIN, D.Sc.

Hon. Treasurer:

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Hon. Librarian:

A. S. KENYON, C.E.

Hon. Secretary:

J. A. KERSHAW.

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PROF. E. W. SKEATS, D.Sc., A.R.C.S., F.G.S.
PROF. W. E. AGAR, F.R.S., M.A., D.Sc.
W. HEBER GREEN, D.Sc.
A. E. V. RICHARDSON, M.A., B.Sc.
H. HERMAN, B.C.E., M.M.E., F.G.S.
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W. GRAY, M.A., B.Sc.

Committees of the Council

House Committee:

THE HON. TREASURER. (CONVENER)
F. WISEWOULD.
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PROF. E. W. SKEATS.

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1923.

LIST OF MEMBERS

WITH THEIR YEAR OF JOINING.

[Members and Associates are requested to send immediate notice of any change of address to the Hon. Secretary.]

PATRON.

His Excellency The Right Hon. The Earl of Stradbroke

HONORARY MEMBERS.

Liversidge, Professor A., LL.D., F.R.S., "Fieldhead," George-road, Coombe Warren, Kingston, Surrey, England. 1892

Verbeek, Dr. R. D. M., Speelmanstraat, 19, s'Gravenhage, Holland. 1886

LIFE MEMBERS.

Fowler, Thos. Walker, M.C.E., "Fernhill," 8 Fitzwilliam-street, Kew. 1879

Gilbert, J. E., 12 Edward-street, Kew, Vic. 1872

Gregory, Prof. J. W., D.Sc., F.R.S., F.G.S., University, Glasgow. 1900

Love, E. F. J., M.A., D.Sc., F.R.A.S., Moreland Grove, Moreland. 1888

Selby, G. W., "Lindisfarne" Scott-grove, E. Malvern. 1881

Smith, W. Howard, "Moreton," Esplanade, St. Kilda ... 1911

Sticht, Rt., B.Sc., M.Am.Inst.M.E., Mt. Lyell Mine, Queenstown, Tasmania. 1913

ORDINARY MEMBERS.

Addison, Stanley, M.B.E., B.Sc., University, Melbourne. 1921

Agar, Prof. W. E., F.R.S., M.A., D.Sc., University Melbourne. 1920

Austin, E. G, Boeri Yallock, Skipton 1922

Baker, Thomas, Bond-street, Abbotsford 1889

Bale, W. M., F.R.M.S., Walpole-street, Kew 1887

Baldwin, J. M., D.Sc., Observatory, South Yarra 1915

Balfour, Lewis, B.A., M.B., B.S., Burwood-road, Hawthorn.	1892
Baragwanath, W., Geological Survey Dept., Melb. ...	1922
Barrett, A. O., 25 Orrong-road, Armadale	1908
Barrett, Sir J. W., K.B.E., C.M.G., M.D., M.S., Collins-street. Melb.	1910
Brittlebank, C. C., 48 York-street, Caulfield	1898
Casey, R. G., Caroline-street, South Yarra	1922
Chapman, F., A.L.S., National Museum, Melb.	1902
Cudmore, F. A., 17 Murphy-street, South Yarra	1920
Davis, Captain John King, "Tasma," Parliament-place, Melbourne.	1920
Deane, H., M.A., M.Inst.C.E., 14 Mercer-road, Malvern	1914
Dunn, E. J., F.G.S., "Roseneath," Pakington-street, Kew.	1893
Dyason, E. C., B.Sc., B.M.E., Equitable Buildings, Collins-street, Melbourne.	1913
Ewart, Prof. A. J., D.Sc., Ph.D., F.L.S., University, Melb.	1906
Gault, E. L., M.A., M.B., B.S., Collins-street, Melb.	1899
Gilruth, J. A., D.V.Sc., M.R.C.V.S., F.R.S.E., 520 Munro-street, South Yarra.	1909
Gray, Wm., M.A., B.Sc., Presbyterian Ladies' College, East Melb.	1913
Green, W. Heber, D.Sc., University, Melbourne	1896
Grimwade, W. Russell, B.Sc., 420 Flinders-lane, Melb.	1912
Grut, P. de Jersey, F.R.Met.S., 103 Mathoura-road, Toorak.	1869
Herman, H., B.C.E., M.M.E., F.G.S., "Albany," 8 Redan-street, St. Kilda.	1897
Horne, Dr. G., Lister House, Collins-street, Melbourne	1919
Kenyon, A. S., C.E., Lower Plenty-road, Heidelberg ...	1901
Kelly, Bowes, Glenferrie-road, Malvern.	1919
Kernot, W. N., B.C.E., University, Melb.	1906
Kershaw, J. A., F.E.S., National Museum, Melb.	1900
Kidson, E., O.B.E., M.Sc., Meteorological Bureau, Melb.	1921
Laby, Prof. T. H., M.A., Sc.D., F.Inst.P., University, Melb.	1915
Laidlaw, W., B.Sc., Department of Agriculture, Melb.	1911

Lewis, J. M., D.D.Sc., "Whitethorn," Boundary-road, Burwood. 1921

Littlejohn, W. S., M.A., Scotch College, Melb. 1920

Lyle, Prof. T. R., M.A., D.Sc., F.R.S., Irving-road, Toorak. 1889

MacKenzie, Colin W., M.D., B.S., F.R.C.S., 88 Collins-street, Melb. 1910

Mahony, D. J., M.Sc., "Lister House," Collins-street, Melb. 1904

Mann, S. F., Caramut, Victoria 1922

Masson, Prof. Orme, M.A., D.Sc., F.R.S.E., F.R.S., University, Melb. 1887

Medley, J. D. G., 223 Walsh street, South Yarra ... 1922

Merfield, C. J., Observatory, South Yarra 1913

Michell, J. H., M.A., F.R.S., 52 Prospect Hill-road, Camberwell. 1900

Millen, The Hon. J. D., Batman House, 103 William-street, Melb. 1920

Miller, Leo. F., "Moonga," Power-avenue, Malvern ... 1920

Miller, E. Studley, 396 Flinders-lane, Melbourne 1921

Monash, Lieutenant-General Sir John, G.C.B., M.C.E., B.A., LL.B., 360 Collins-street, Melb. 1913

Oliver, C. E., M.C.E., Mt. Dandenong North 1878

Osborne, Prof. W. A., M.B., B.Ch., D.Sc., University, Melb. 1910

Owen, W. J., "Gaergybi," 935 Rathdown-street, Nth. Carlton. 1919

Patton, R. T., B.Sc., M.F., Biology School, University, Melbourne. 1922

Payne, Prof. H., M.Inst.C.E., M.I.M.E., University, Melb. 1910

Picken, D. K., M.A., Ormond College, Parkville 1916

Piesse, E. L., Prime Minister's Department, Melbourne 1921

Pratt, Ambrose, M.A., 376 Flinders-lane, Melb. 1918

Quayle, E. T., B.A., Meteorological Bureau, Melb. ... 1920

Richardson, A. E. V., M.A., B.Sc., Agricultural Department, Melb. 1912

Schlapp, H. H., 31 Queen-street, Melb. 1906

Shephard, John, "Norwood," South-road, Brighton Beach. 1894

Skeats, Prof. E. W., D.Sc., A.R.C.S., F.G.S., University, Melb. 1905

Spencer, Prof. Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., "Darley," Upper Fern Tree Gully. 1887

Stievens, John Lloyd, 34 Queen-street, Melbourne ... 1922

Summers, Associate Prof. H. S., D.Sc., University, Melb. 1902

Sweet, Associate Prof. Georgina, D.Sc., University, Carlton. 1906

Swinburne, Hon. G., M.Inst.C.E., M.Inst.M.E., "Shenton," Kinkora-road, Hawthorn. 1905

Thirkell, Geo. Lancelot, B.Sc., 4 Grace-street, Malvern. 1922

Trinder, E. E., "Ruzilma," Orrong-grove, Caulfield 1922

Watt, W. S., Weather Bureau, Victoria-street, Melb. 1922

Walcott, R. H., Technological Museum, Melb. 1897

Wisewould, F., "Mona," Pakenham Upper, Victoria 1902

Woodruff, Prof. H. A., M.R.C.S., L.R.C.P., M.R.C.V.S., Veterinary School, University, Melb. 1913

Country Members.

Crawford, W., Gisborne 1920

Dare, J. H., B.Sc., Elementary High School, Warracknabeal. 1917

Drevermann, A. C., Longerenong Agricultural College, Dooen. 1914

Easton, J. G., Geological Survey, Corryong 1913

Ferguson, E. W., M.B., Ch.M., "Timbrebongie," Gordon-road, Roseville, Sydney, N.S.W. 1913

Harris, W. J., B.A., High School, Echuca 1914

Hart, T. S., M.A., B.C.E., F.G.S., School of Mines, Bairnsdale, Vic. 1894

Hogg, H. R., 2 Gresham Buildings, Basinghall-street, London, E.C.2.

Hope, G. B., B.M.E., "Carrical," Hermitage-road, Newtown, Geelong, 1918

James, A., B.A., B.Sc., High School, St. Arnaud 1917

Kitson, A. E., F.G.S., C.M.G., C.B.E., 29 Alfred-place, S. Kensington, London, S.W.7, England. 1894

Langford, W. G., M.Sc., B.M.E., Vailala Oilfields, Popo, via Port Moresby, Papua. 1918

Lea, A. M., F.E.S., 241 Young-street, N. Adelaide, S. Australia. 1909

Richards, Prof. H. C., D.Sc., University, Brisbane, Queensland. 1909

Trebilcock, Captain, R. E., M.C., Wellington-street, Kerang. 1921

Turner, A. Jefferis, M.D., F.E.S., Wickham Terrace, Brisbane. 1922

White, R. A., B.Sc., School of Mines, Bendigo, Vict. 1918

CORRESPONDING MEMBERS.

Dendy, Professor Arthur, D.Sc., F.R.S., Sec. L.S., King's College, London. 1888

Lucas, A. H. S., M.A., B.Sc., Sydney Grammar School, Sydney, N.S.W. 1895

Merrel, F. P., Rhodesian Museum, Buluwayo, South Africa. 1919

ASSOCIATES.

Allen, Miss N. C. B., B.Sc., Physics Dept., University, Melb. 1918

Archer, Howard R., B.Sc., Geology School, University 1921

Armitage, R. W., M.Sc., F.G.S., F.R.G.S., 95 Foam street, Elwood. 1907

Ashton, H., "The Sun," Castlereagh-street, Sydney, N.S.W. 1911

Bage, Mrs. Edward, "Cranford," Fulton-street, St. Kilda, 1906

Bage, Miss F., M.Sc., Women's College, Kangaroo Point, Brisbane, Queensland. 1906

Baker, F. H., 167 Hoddle-street, Richmond 1911

Barkley, H., Meteorological Bureau, Melb. 1910

Bordeaux, E. F. J., G.M.V.C., B.èsL., 427 Mount Alexander-road, Moonee Ponds. 1913

Breidahl, H., M.Sc., M.B., B.S., 36 Rouse-street, Port Melb. 1911

Brodribb, N. K. S., Cordite Factory, Maribyrnong 1911

Brookes, Leslie R., B.A., High School, Echuca 1922

Bryce, Miss L. M., B.Sc., 22 Victoria-avenue, Canterbury. 1918

Buchanan, G., D.Sc., University, Melb. 1921

Chapple, Rev. E. H., The Manse, Warrigal-road Oakleigh. 1919

Clinton, H. F., Produce Office, 605 Flinders-street, Melb. 1920

Cook, G. A. M.Sc., B.M., 18 Elphin-grove, Hawthorn 1919

Cookson, Miss I. C., B.Sc., 154 Power-street, Hawthorn 1916

Coulson, A. L., M.Sc., "Finchley," King-street, Elsternwick. 1919

Cousins, Miss M., c/- Mr. Pearson, Palermo-street, Mentone. 1922

Crespin, Miss R., B.A., Geology School, University, Melbourne. 1919

Cronin, J., Botanical Gardens, South Yarra 1921

Danks, A. T., 391 Bourke-street West, Melb. 1883

Dunstan, Joseph, Geology School, University, Melb. 1922

Fenner, C. A., D.Sc., Education Department, Flinders-street, Adelaide, S.A. 1913

Fenton, J. J., 20 Northcote-road, Armadale 1910

Ferguson, W. H., 37 Brinsley-road, E. Camberwell ... 1894

Finney, W. H., 40 Merton-street, Albert Park 1881

Flecker, Dr. H., 4 Collins-street, Melbourne ... ... 1922 Yarra.

Gabriel, C. J., 293 Victoria-street, Abbotsford 1908

Gordon, Miss M., B.Sc., Botany School, University, Melb. 1919

Hardy, A. D., F.L.S., Forest Department, Melb. 1903

Hauser, H. B., B.Sc., Geology School, University, Melb. 1919

Hoadley, C. A., M.Sc., B.M.E., c/o Richardson Gears, Footscray. 1910

Holmes, W. M., M.A., B.Sc., University, Melb. 1913

Hosking, J. B. O., B.M.E., Observatory, Domain, South Yarra. 1922

Howitt, A. M., Department of Mines, Melb. 1910

Jack, A. K., M.Sc., 49 Aroona-road, Caulfield 1913

Jona, J. Leon, M.D., B.S., D.Sc., "Hazelmere," Wattle Tree-road, Malvern. 1914

Jones, Miss K. A. Gilman, Church of England Girls' Grammar School, Anderson-street, S. Yarra. 1922

Jutson, J. T., B.Sc., "Oakworth," 2 Austin-avenue, St. Kilda. 1902

Keartland, Miss B., B.Sc., Cramer-street, Preston ... 1919
Keble, R. A., Department of Mines, Melb. 1911
Kerr, Miss Lesley Ruth, Biology School, University, Carlton. 1922

Lambert, C. A., Bank of N.S.W., Melbourne 1919
Luher, R. E., B.A., 101 Hickford-street, E. Brunswick 1919
Luly, W. H., Department of Lands, Public Offices, Melb. 1896

McInerney, Miss K., M.Sc., Geology School, University, Melb. 1918
Macdonald, B., Central Weather Bureau, Melbourne 1920
Mackenzie, G., 1 High-street, Prahran 1907
Maclean, C. W., "Devon," Merton-avenue, Elsternwick 1879
McLennan, Ethel, D.Sc., Botany School, University, Melb. 1915
Melhuish, T. D. A., B.A., Port Pirie, South Australia 1919
Mollison, Miss E., M.Sc., Royal Crescent, Camberwell 1915
Moore, F. E., M.B.[illegible] 4 Mont Albert-road West, East Kew. 1920
Morris, P. F., National Herbarium, S. Yarra 1922

Nicholson, Miss Margaret G., 59 Murray-street, Elsternwick. 1920

Oke, C., 56 Chaucer-street, St. Kilda 1922
Osborne, Miss A., B.Sc., Biology School, University, Melb. 1918

Pern, Dr. Sydney, 16 Collins-street, Melb. 1920
Peterson, Miss K., B.Sc., Biology School, University, Melb. 1919
Pretty, R. B., 99 Primrose-street, Essendon 1922

Raff, Miss J., M.Sc., University, Melb. 1910
Rivett, Assoc. Prof. A. C. D., M.A., D.Sc., University, Melb. 1914
Rosenthal, Newman H., 427 Cardigan-street, Carlton 1921
Rossiter, Captain A. L., M.Sc., University, Melb. 1913

Scott, T. F., M.A., High School, Warragul 1917
Sharman, P. J., M.Sc., "Glenalvie," 9 Daphne-street, Canterbury. 1916
Showers, Alan, Geology School, University, Melbourne 1922
Singleton, F. A., M.Sc., Geology School, University, Melb. 1917

Smith, J. A., 15 Collins-place, Melb. 1905
Stickland, John, 433 Brunswick-street, Fitzroy 1922
Stillman, Miss G., "Taiyuan," 3 Grange-road, Kew 1919
Stillwell, F. L., D.Sc., 44 Elphin-grove, Hawthorn ... 1910
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The names of new genera and species are printed in italics.

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CONTENTS OF VOLUME XXXVI.

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. I., 1923].

ART. I.—*On Australian Aphodiides (Coleoptera).*

By ARTHUR M. LEA, F.E.S.

[Read, 8th March, 1923.]

The Australian Aphodiides were revised in these Proceedings for 1904 by the late Rev. T. Blackburn, when he stated that all the species described as new could be placed in their genera "strictly on the characters cited" in the table of genera supplied. The new species here dealt with have also been referred to genera in accordance with that table, although it separates two species: *Ataenius aphodioides* and *Aphodius heterodoxus*, which at first glance appear to be congeneric. Since the revision the following species have been recorded as Australian:

Aphodius ambiguus, Boh., Freg. Eng. Resa, ii. (1), 1858, p. 51, *frenchi* Blackb.
A. distinguendus, Schmidt, Deutsch. Ent, Zeit., 1910, p. 354, (*Mendidius*).
A. sorex, Fab., Ent. Syst., i., 1792, p. 23. Introduced.
Dialytes granifer, Schmidt, Soc. Ent. Zurich, 1909, xxiv., p. 66.
Odochilus syntheticus. Har., Ann. Mus. Civ. Gen., x., 1877, p. 99; Schmidt, Wyts. Gen. Ins. Fasc. cx., 1910, pl. 3, fig. 40.
Phycochus graniceps, Broun. Man. N.Z. Col., iii., 1886, p. 771.
P. sulcipennis, Lea, Proc. Linn. Soc., N. S. Wales, 1904, p. 89, pl. 4, fig. 10.
Rhyssemus blackburni, Clouet, Mem. Soc. Ent. Belg., 1901, p. 50, pl. 3, fig. 18.

I do not know *Dialytes* and *Odochilus*, but *Phycochus* is distinct by the eyes being absent or very minute and *Rhyparus* (a species of which is named below) by having six longitudinal ridges on the prothorax.

APHODIUS AMBIGUUS, Boh.

A. frenchi, Blackb.

Widely distributed in both Africa and Australia, but first named from the former. Two other synonyms (*A. tarsalis*, Schmidt and *A brevitarsis*, Pering) and one variety (*A. accola*, Kolbe) are noted in Junk's Catalogue of the sub-family (1910, part 20).

APHODIUS HETERODOXUS, sp. nov.

Bright reddish-castaneous, most of prothorax infuscated.

Head strongly convex, base impunctate, then with a few large punctures, but apical two thirds closely covered with small granules.

Prothorax about four-fifths as long as wide, sides moderately rounded, front angles slightly produced, hind ones rounded, lateral margins slight, basal ones slight at sides and not traceable across middle; with large and sparsely distributed punctures, mixed with a few minute ones. Elytra almost parallel-sided to beyond the middle-punctate-striate, interstices evenly convex and much wider than striae, even on apical slopes. Under-surface with pale irregularly distributed hairs. Metasternum between middle and hind coxae with an elliptic depression, its middle with a narrow-deep stria; the sides with coarse, asperate punctures. Apical segment of abdomen with a median depression. Middle and hind femora dilated in middle, their tibiae strongly dilated at apex.

Length, 4.75—5mm.

Hab.—South Australia: Port Augusta.

I am somewhat dubious as to the generic position of this species. The elytra are certainly without a basal edging (a specimen has been dissected to make sure of this), so by Blackburn's table it cannot belong to *Ataenius* or *Psammodius*; the middle coxae are much less widely separated than in *Proctammodes sculptus* or *P. minor*, but more than in the British *Aphodius granarius* or *A. nutidulus*. The separation, however, is very little more than in *A. subterraneus*, so at present it appears desirable to refer it to *Aphodius*. In general appearance it is much like *Psammodius zietzi*. On one specimen the prothorax, except at the sides and in front, is almost black. The punctures in the elytral striae are small and shallow, but, owing to "waterlogging," from some directions they appear to be large, subquadrate, and almost as wide as the interstices.

A specimen from New South Wales (Broken Hill, Simson's collection) possibly belongs to this species, but its head is partly infuscated with smaller and less defined granules; prothorax deep black except at the sides, with decidedly smaller and even sparser punctures; elliptic depression of metasternum shallow, depression on apical segment of abdomen smaller and shallower, and teeth of front tibiae less acute. Some of these differences, however, may be sexual.

Aphodius integrifrons, sp. nov.

Of a dingy livid colour, but shining, antennae and femora paler, base of head deeply infuscated, most of prothorax feebly infuscated, tibiae somewhat reddish. Under-surface with long yellowish setae, mixed with sparse, whitish pubescence; legs with setae only; elytra with very fine, depressed setae.

Head almost semicircular, but suddenly narrowed near front of eyes; apex not incurved at middle, sides gently elevated; base almost impunctate, elsewhere with moderately large, scattered punctures, denser between eyes than elsewhere. Prothorax almost twice as wide as long, sides evenly rounded, with thickened margins, front angles slightly produced, hind ones rounded off, base bisinuate, finely margined at sides but not in middle; with scattered punctures, about as

large as those on head. Elytra almost parallel-sided to beyond the middle; with narrow geminate striae, interstices wide, feebly separately convex, each with a row of small, setiferous punctures. Metasternum with a deep median stria; with sparse punctures, becoming more numerous but not crowded on sides,

Length, 7.5 mm.

Hab.—Queensland: Cairns (H. Hacker).

In Blackburn's table this species would be placed with *A. lividus*, to which it is not at all close, but it is really allied to *A. suberosus*, *A. victoriae* and similar species, although the elytral interstices are nowhere tuberculate or alternately elevated; there is a single row of minute depressed setae on each interstice.

APHODIUS TRICOLOR, sp. nov.

Black, parts of under-surface obscurely diluted with red, elytra dark red, sides and suture infuscated, antennae reddish, club darker; legs flavous, some parts infuscated or reddish. With rather long, suberect, reddish hairs.

Head with coarse and fairly dense punctures, margins elevated throughout, truncated in front, dilated near eyes. Eyes with distinct facets. Prothorax almost twice as wide as the median length, sides strongly rounded, notched at base, median line distinct near base, vanishing before apex; punctures coarse and rather dense but somewhat irregular. Scutellum almost impunctate. Elytra with rather deep and narrow striae, odd interstices conspicuously and evenly elevated and with coarse punctures, even interstices wider than the others, and with dense, asperate punctures of two sizes. Front tibiae with two strong teeth and one small one, and with several denticulations.

Length, 5 mm.

Hab.—New South Wales: Collarenebri (Dr. J. F. Illingworth from S. W. Jackson).

The punctures on the pronotum are large but not very even, so that it is doubtful as to whether Blackburn would have associated this species with *AA*, *BB*, *C*, or *CC* in his table; it is, however, very distinct from all the species dealt with by him, by the black coarsely sculptured prothorax, and red elytra with strong and almost even elevation of the odd interstices. The notch on each side of the prothorax is much more pronounced on one specimen than on another.

APHODIUS BICRENULATUS, sp. nov.

Of a livid brown and shining, sides and apical slope of elytra and parts of under-surface and of legs paler. Upper-surface with depressed and rather sparse pale pubescence, under-surface and legs with still sparser pubescence, and a few short setae.

Head with crowded and fairly large punctures, a short transverse ridge near each eye, sides dilated and somewhat sinuous, apex strongly incurved at middle. Prothorax about three-fifths as long

as wide, sides widest near base and rather widely margined, front angles produced, hind ones rounded, base finely margined, median line distinct except at apical fifth; punctures about as large as on head, but much less numerous. Elytra with sides feebly rounded to beyond the middle, interstices gently separately convex, the even ones slightly wider than the odd ones; with irregular rows of distinct punctures, each interstice, except the sutural and lateral ones, crenulate on each side. Metasternum with a feeble median line; with sparse punctures, becoming more numerous on sides but not crowded.

Length, 5 mm.

Hab.—Western Australia: Mount Barker (R. Helms).

The elytral striae from some directions appear to be much wider than they really are, and each to contain a row of large transverse punctures, but this is due to the crenulation on each side of each interstice, except the sutural and lateral ones, which are crenulate on one side only. I know of no closely allied species from Australia or elsewhere.

Aphodius parvoniger, sp. nov.

Deep black and shining, sides of prothorax and tips of elytra with some obscure livid markings, parts of legs obscurely diluted with red.

Head with minute punctures, fairly distinct near base, but scarcely visible, if at all, elsewhere; front slightly incurved to middle. Prothorax about four-fifths as long as wide, sides moderately rounded and feebly margined, base more strongly rounded with margins traceable only on sides, front angles scarcely produced, hind ones widely rounded off; with fairly large and numerous but not crowded punctures, becoming smaller in front. Elytra with sides feebly dilated to beyond the middle, punctate-striate, punctures rather large but shallow, and with a lined appearance; interstices rather strongly convex and wider than striae, except posteriorly, where they are narrower. Metasternum subopaque and with shallow asperate punctures on sides, shining and with minute ones elsewhere; a narrow-deep median stria.

Length, 3—3.5 mm.

Hab.—Western Australia: Swan River (J. Clark and A. M. Lea).

A small, narrow, deep black species, at first appearing to belong to *Ataenius*, but elytra without basal edging, and shoulders rounded and unarmed. On two specimens the front sides of the prothorax are obscurely pale, on three others the pale parts can scarcely be traced; on one of the former, and one of the latter the pale markings on the apical slope of the elytra are rather sharply defined, on the others they are feeble and almost, or quite, confined to the apical margin.

ATAENIUS CRENATIPENNIS, Macl. (*Ammoecius*).

A. speculator, Blackb.

A. crenatipennis was described from Gayndah, *A. speculator* from the Victorian Alps. Blackburn, however, subsequently identified specimens from the Clarence River as belonging to *speculator*, and the species is a widely distributed one, occurring in Queensland, New South Wales, Victoria, South and North-Western Australia, and Lord Howe Island. It is the only conspicuously setose species of the genus from Australia; a few others have elytral setae but they are so small as to be scarcely visible, and only from the sides.

ATAENIUS OBSCURUS, Macl. (*Ammoecius*).

The specimens that Blackburn thought[1] might belong to this species are not even near it; in his table the type would be referred to AA, BB, and perhaps to CC, but it is very different from *A. walkeri*, the only species referred to CC.

ATAENIUS BASICEPS, sp. nov.

Black, opaque, legs dull red, antennae and tarsi paler.

Head with coarse, crowded punctures, on a rather narrow and sharply defined basal space, front with fairly numerous small punctures, between it and the basal punctures smooth and scarcely visibly punctate. Prothorax at apex almost twice as wide as the median length, front angles obtusely produced, sides with moderate margins; punctures coarse and crowded as on base of head. Elytra almost parallel-sided to near apex, each shoulder with a short oblique spur; narrowly striate, and narrowly costate, between each costa and stria a row of large punctures, and granules. Metasternum with coarse, crowded punctures, and a narrow median line.

Length, 4—4.5 mm.

Hab.—New South Wales: Albury (Rev. T. Blackburn).

The punctures at the base of the head are about the same size as on *A. koebelei* and *A. imparilis*, but on those species the punctures on the convex median part are very dense and conspicuous, on the present species that part is practically impunctate. The sides of the head and of the prothorax are very narrowly and obscurely reddish. The elytral sculpture appears to vary with the point of view, from directly above each costa and stria appears to be very narrow, with a row of large intervening punctures; each of the punctures with a granule where it adjoins the stria; from behind, the punctures are much less evident, but the granules and alternate costae are distinct; from the sides the striae and punctures disappear, and a row of evenly spaced granules alternate with a narrow costa. A specimen from Tasmania (Simson collection) probably belongs to the species, but is smaller and the sculpture between its elytral striae and costae is less defined.

1. Blackb., Proc. Roy. Soc. Vic., 1904, p. 162.

ATAENIUS DUPLOPUNCTATUS, sp. nov.

Black, shining, legs dull red, antennae paler. Prothorax fringed with pale setae.

Head rather convex, with moderately large punctures at base, smaller and denser elsewhere, but with a tendency to become subgranulate at the sides. Prothorax about three-fifths as long as wide, sides gently rounded, front angles slightly produced, hind ones rounded off, sides and base finely margined; with small and rather dense punctures, interspersed with larger ones, except about apex in middle. Elytra parallel-sided to near apex, shoulders feebly armed; striate-punctate, interstices gently and evenly convex, crenulate internally, and wider than striae, but posteriorly narrowed so as to be no wider than striae. Metasternum with a narrow deep median stria, an oblique and rather shallow depression near each hind coxa; with small and fairly dense punctures near sides, elsewhere almost impunctate. Mesosternum with a narrow, shining, intercoxal carina.

Length, 5—6 mm.

Hab.—Western Australia: Parkerville (J. Clark); South Australia: Port Noarlunga and Mount Lofty (N. B. Tindale); Victoria: Forrest (H. W. Davey), Noble Park and Linga (F. E. Wilson).

The largest of all the shining black species from Australia; on most of the specimens the front of the head is obscurely reddish. The parts about the middle coxae, and the flanks of the prosternum are moderately densely clothed.

ATAENIUS LAEVIFRONS, sp. nov.

Black, shining, legs more or less obscurely reddish, antennae palpi and tarsi paler. Sides of prosternum moderately densely clothed.

Head with fairly dense, and not very large, but sharply defined punctures about base, smaller and sparser elsewhere, and scarcely or not at all traceable in middle. Prothorax about three-fifths as long as wide, sides gently rounded, front angles slightly produced, hind ones rounded off, sides and base rather narrowly but conspicuously margined; with fairly large and dense punctures, becoming crowded on sides, but absent from a narrow, polished, apical space. Elytra parallel-sided to near apex, shoulders slightly armed; striate-punctate, interstices gently and evenly convex, strongly crenulate internally, much wider that striae, but posteriorly becoming very narrow and distinctly narrower than striae. Metasternum with a narrow, deep, median stria, an oblique impression containing numerous punctures near each hind coxa; sides with crowded and rather small, asperate punctures, a few large sharply defined ones about middle. Mesosternum with a very narrow carina on intercoxal process.

Length, 4.25—4.5 mm.

Hab.—Queensland: Stewart River (W. D. Dodd).

About the width of *A. duplopunctatus*, but shorter, head with smaller punctures, no small punctures amongst the larger ones on prothorax, and parts of under-surface different. It is larger than *A. eurynotus*, punctures of head in middle scarcely visible, and crenulation of elytral interstices more pronounced. On some specimens the legs, except the tarsi, are almost black.

ATAENIUS EURYNOTUS, sp. nov.

Black, shining, antennae palpi and legs reddish, sides of head and of prothorax obscurely reddish.

Head with small, dense punctures, becoming larger and more sharply defined about base. Prothorax almost twice as wide as long, sides slightly rounded, front angles obtusely produced, hind ones oblique, lateral and basal margins distinct; punctures of moderate size and rather crowded on sides, sparse in middle, and absent from a narrow, shining space at apex, with a few minute punctures scattered about. Elytra parallel-sided to near apex, shoulders feebly armed; striate-punctate, interstices gently convex and wider than striae, crenulate internally, posteriorly becoming much narrower, and narrower than striae. Metasternum with a deep impress on at base and apex, representing a median stria, a shallow oblique impression filled with small punctures near each hind coxa, sides with small crowded punctures, a few fairly large ones about middle.

Length, 4 mm.

Hab.—Queensland: Normanton (R. Kemp).

A short, wide species, in general appearance fairly close to *A. semicaecus*, but slightly wider, and without minute granules in front. The deep median impressions on the metasternum from most directions appear to be disconnected, but from some directions they appear to be very feebly connected on each of the two specimens taken by Mr. Kemp.

ATAENIUS PARVUS, sp. nov.

Black, shining; antennae, palpi and legs reddish.

Head rather strongly convex, with rather sharply defined punctures at extreme base, elsewhere impunctate. Prothorax almost twice as wide as long, front angles obtusely produced, hind ones gently rounded, sides feebly rounded and moderately margined, base feebly margined; with sharply defined punctures of moderate size, denser on sides than elsewhere, and absent from a narrow, shining space at apex. Elytra with sides feebly rounded to beyond the middle, shoulders scarcely armed; striate-punctate, interstices gently convex, wider than striae, and rather feebly crenulate internally, posteriorly becoming thin and narrower than striae. Metasternum with a narrow, deep stria in middle, a shallow oblique impression with a few small punctures near each hind coxa; sides opaque and with minute punctures, middle shining and impunctate. Metasternum with a very fine carina on intercoxal process.

Length, 2.5—2.75 mm.

Hab.—Western Australia: Vasse (A. M. Lea).

A small, rather strongly convex species, with clypeal flanges rather wider than usual; it is about the size of *A. walkeri*, but is shining, prothorax with much sparser and considerably larger punctures, elytral interstices much wider, &c.; at first glance it appears to belong to *Aphodius*, but the elytra are margined at the base.

ATAENIUS SPINIPENNIS, sp. nov.

Black, subopaque, sides of clypeus, palpi and legs obscurely reddish, antennae paler.

Head with crowded and small punctures, becoming somewhat larger at base, and sparser but more sharply defined on sides of clypeus. Prothorax about three-fifths as long as wide, sides feebly dilated to near apex, front angles rounded and slightly produced, hind ones oblique, lateral and basal margins feeble; with rather small, crowded punctures. Elytra parallel-sided to near apex, shoulders acutely spined; narrowly striated, interstices strongly crenulated internally, ridged externally. Metasternum with a narrow, deep median stria, some large punctures near it, a shallow oblique impression containing small punctures.

Length, 3.5—4 mm.

Hab.—Queensland: Thursday Island (N. B. Tindale).

From some directions the elytra appear to have narrow interstices separating rows of fairly large even granules, from others to have rows of strong subquadrate punctures, but these appearances are really due to the strong crenulation of the inner part of each interstice; on the apical slope, however, the interstices are narrowly costate and separate rows of large punctures. On four of the eight specimens before me the elytra and under-surface are of a rather dingy red, probably from immaturity. The shoulders are more acutely spined than on any other known Australian species of the genus.

ATAENIUS INSULARIS, sp. nov.

Black, shining; sides of clypeus and legs more or less obscurely reddish, antennae paler.

Head with rather small, crowded punctures, but suddenly becoming larger near base. Prothorax almost twice as wide as long, sides feebly rounded, front angles rounded, and slightly produce, hind ones oblique or slightly coarctate, lateral and basal margins fine; with dense and rather small but sharply defined punctures, becoming crowded on sides, especially in front angles, and very fine across middle of apex. Elytra parallel-sided to near apex, shoulders rather feebly armed; striate-punctate, interstices evenly convex and wider than striae, posteriorly becoming narrower than striae. Metasternum with a narrow, deep median stria, middle shining but with a few distinct punctures near base, a shallow oblique impression filled with small punctures near each hind coxa; sides opaque, with small

crowded punctures. Mesosternum with a very narrow ridge on intercoxal process.

Length, 3.5—3.75 mm.

Hab.—Queensland: Moa or Bank's Island (G. F. Hill).

With the general appearance of *A. macilentus*, but head with dense and quite conspicuous punctures on the convex median part; also like large *A, torridus*, but base of head with larger punctures, sharply defined in front from the smaller ones, so as to be like those of *A. basiceps* on a reduced scale; the prothorax is more convex longitudinally than on *A. persimilis*; the head not granulate in front distinguishes from *A. semicaccus; A. nudus* has sparser prothoracic punctures and head scarcely visibly punctate in middle. The crenulation of the elytral interstices is so slight that from most directions the punctures appear to be confined to the striae. On one specimen each of the abdominal segments has a shining impunctate space across its apical third, on a second specimen the punctures are evenly distributed; the difference is probably sexual. A specimen from Normanton (R. Kemp) possibly belongs to this species, but its prothorax is slightly wider, with distinct'y sparser punctures (except that they are crowded on the sides), and elytral striae deeper, with their punctures even less distinctly crenulating the interstices.

Ataenius persimilis, sp. nov.

Blackish; sides of head, antennae, palpi and legs reddish.

Head with fairly dense sharply defined punctures of moderate size near base, elsewhere obsoletely granulate. Prothorax about twice as wide as long, front angles slightly produced, hind ones rounded, lateral and basal margins slight, with fairly dense, sharply defined punctures, becoming crowded on parts of sides, a narrow space across apex polished and with minute punctures. Elytra almost parallel-sided to beyond the middle, shoulders very feebly armed; interstices apparently rather narrow, strongly crenulate internally, and slightly so externally. Metasternum with a deep, narrow median stria, no punctures adjacent to it, a shallow oblique impression with small punctures near each hind coxa; sides opaque and with crowded punctures. Mesosternum with a narrow median carina on intercoxal process.

Length, 3.25—3.75 mm.

Hab.—Northern Territory: Roper River (N. B. Tindale), Tennant's Creek (J. F. Field); North-Western Australia: Derby (W. D. Dodd).

In general appearance like *A. latericollis*, but consistently larger, prothorax with somewhat larger punctures and elytral interstices more strongly crenulate; from *A. semicaccus* and *A. goyderensis* it differs in being smaller, less polished, cephalic granu'es less sharply defined, prothoracic punctures larger and less crowded, and elytra more strongly crenulate; from *A. semicornutus* in being somewhat wider, with finer sculpture of head, elytra different and prothorax

without trace of a median line. The strong crenulation of the interstices causes the elytra to appear to have strong punctate-striae, wider than the interstices, but allowing for the crenulation the interstices are real'y wider than the striae, except posteriorly, where they are narrower and costiform.

ATAENIUS MICROTRICHOPTERUS, sp. nov.

Black or blackish and moderately shining; front and sides of head, antennae, palpi and legs more or less reddish. Elytra with series of very minute setae, similar setae on sides of prothorax.

Head with dense and rather sharply defined punctures of moderate size, becoming longitudinally confluent in middle. Prothorax almost twice as wide as long, front angles feebly produced, basal ones oblique, sides feebly margined and very feebly crenulated; with dense punctures of moderate size, becoming smaller (but still well-defined) in front, and crowded on sides; median line distinct at base and traceable to beyond the middle. Elytra parallel-sided to near apex, shoulders rather acutely armed; interstices fairly wide near sides, rather narrowly ridged and strongly crenulated towards suture, each with two rows of minute setiferous punctures. Metasternum with a deep median stria, adjacent to which are sharply defined but not crowded punctures, a shallow oblique impression filled with small punctures near each hind coxa; sides with crowded punctures. Length, 3.5—4 mm.

Hab.—Queensland: Cunnamulla (H. Hardcastle).

In Blackburn's table would be associated with *A. australis*, from which it differs in having the elytral interstices less narrow near the suture, and metasternum with much sparser punctures, those of the abdomen also decidedly smaller and sparser; it is somewhat wider than *A. semicornutus*, prothorax less convex, with decidedly denser and somewhat smaller punctures, and those on elytra more distinct; the prothorax with remnant of a median line distinguishes it from *A. deserti*. The setae of the upper-surface are very thin and short, and are distinct only from the sides. The species is close to a specimen marked as a cotype of *A. sparsicollis*, but is slightly wider and black, the elytral interstices, in addition to their inner crenulation, have two rows of small punctures; it is to be noted, however, that on the cotype of *sparsicollis* the punctures on the prothorax are very little different from those on *A. australis*, instead of being very different as noted in the description; I do not regard the name, however, as a synonym of *australis*. Four specimens from Australia (Simson's collection) and one from New South Wales (Belmore, F. Taylor) possibly belong to this species, but are smaller (2.75—3 mm.), on three of them (including the Belmore specimen) the median line of the prothorax is represented by a scarcely visible basal remnant. from the others it is quite absent.

ATAENIUS INTEGRICOLLIS, sp. nov.

Black or blackish and somewhat shining; front of head, antennae, palpi and legs more or less reddish.

Head with dense and well-defined punctures at base and on sides of clypeus, elsewhere impunctate or almost so. Prothorax about three-fifths as long as wide, front angles slightly produced, hind ones rounded, margins of base and sides moderate; with dense and sharply defined but not very large punctures, smaller in front than near base, and crowded on sides. Elytra parallel-sided to near apex, shoulders feebly armed, interstices rather strongly ridged externally, strongly crenulated internally. Metasternum as described in preceding species. Length, 3.5—4 mm.

Hab.—Queensland: Cunnamulla (H. Hardcastle).

In general appearance close to the preceding species, but upper-surface glabrous, head with much smaller punctures (scarcely visible) on convex median portion, and prothorax without median line; in Blackburn's table it would be associated with *A. deserti*, from the description of which it is at once distinguished by the cephalic punctures; from *A. macilentus* it differs in the denser punctures of prothorax and very different elytra. From some directions the elytra appear to have rows of large punctures, alternating with narrow costae; on altering the point of view the punctures appear to change to regular rows of small granules; these appearances are due to the crenulated inner portion of each interstice being below its outer portion. From some directions the basal portion of the prothorax appears finely multigranulate. On several specimens the elytra, wholly or in part, front and sides of prothorax, and most of under-surface, are of a more or less dingy reddish-brown.

Ataenius illaetabilis, sp. nov.

Black, opaque; front of head, antennae, palpi and legs reddish.

Head with crowded punctures, becoming longitudinally confluent in the middle, and sparse on clypeus. Prothorax almost twice as wide as long, front angles somewhat produced, hind ones oblique; with crowded punctures throughout. Elytra parallel-sided to near apex, shoulders slightly armed; interstices obtusely ridged externally, crenulated internally. Under-surface with crowded punctures throughout. Mesosternum with a deeply impressed, narrow median line. Length, 3—3.5 mm.

Hab.—North-Western Australia: Fortescue River (W. D. Dodd).

An opaque species, except that the under parts are somewhat shining, which in Blackburn's table of the genus would be associated with *A. walkeri*, from which it differs in being consistently larger, prothorax slightly wider and less parallel-sided. The under-surface of most of the specimens (of which twenty-four were taken by Mr. Dodd) is of a dingy reddish-brown; two specimens are entirely pale reddish-brown, probably due to immaturity. The sides of the prothorax, as seen from below, are distinctly crenulated or serrated on the basal half only, but from above this is scarcely evident; from some directions the elytral interstices appear to be wider than the striae, and these to contain distinct punctures; from others, however, the punctures are seen to be really due to the crenulation of the depressed inner portion of each interstice.

ATAENIUS APHODIOIDES, sp. nov.

Bright reddish-castaneous, antennae somewhat paler, head, except in front, and most of prothorax somewhat infuscated.

Head moderately convex, with crowded and rather small but sharply defined punctures, becoming larger and subgranulate in front. Prothorax almost twice as wide as long, sides moderately rounded, front angles produced, the hind ones rounded, lateral and basal margins slight; with fairly dense punctures, about as large as at base of head but less crowded, and interspersed with numerous fairly large ones. Elytra subparallel-sided to near apex, base finely margined, shoulders unarmed; punctate striate, punctures slightly encroaching on interstices, these gently convex and much wider than striae, even on apical slope; with small punctures more distinct near sides than near suture. Metasternum with a narrow median stria, minute punctures near it, a very feeble oblique impression near each hind coxa; sides with fairly dense but inconspicuous punctures. Length, 4.5—4.75 mm.

Hab.—Western Australia: Cue (H. W. Brown).

With the general appearance of *Aphodius heterodoxus*, but elytra with basal edging, and prothorax with crowded punctures; also with the general appearance of *Psammodius zietzi*, but head with granules only in front and hind femora much less dilated, although rather more strongly than is usual in *Ataenius*.

PROCTAMMODES METASTERNALIS, sp. nov.

Black, highly polished; front of head and parts of antennae and of legs more or less obscurely reddish.

Head almost impunctate at base, with fairly numerous and small but sharply defined punctures between eyes, becoming denser elsewhere but very minute in middle; sides moderately curved; front strongly incurved to middle. Prothorax about four-fifths as long as wide, sides gently rounded and finely margined, front angles obtusely produced, hind ones rounded, base rather strongly rounded in middle and finely margined only at sides; punctures of moderate size, sharply defined and not very dense, becoming smaller in front. Elytra with sides almost parallel to near apex, shoulders rounded; punctate-striate, punctures round, sharply defined and slightly encroaching on interstices, these scarcely separately convex, much wider than striae, becoming narrower posteriorly, but even there wider than striae. Metasternum with an almost circular depression in middle, surrounded by a flattened ring with small punctures, its middle with a narrow stria; an oblique impunctate depression on each side near hind coxa, sides with crowded punctures. Middle coxae widely separated. Length, 3.75—4 mm.

Hab.—Queensland: Brisbane (Mrs. C. Lea).

Somewhat resembling *P. minor*, but punctures on head smaller, prothorax without remnant of a median line and with sparse punc-

tures, punctures of elytra less encroaching on interstices, and metasternum with a round median depression.

SAPROSITES NITIDICOLLIS, Macl. (*Ammoecius*).

The specimens in his collection that were commented upon and tabled by Blackburn[1] somewhat doubtfully as *Ammoecius nitidicollis*, and which he then transferred to *Saprosites*, agree with the types.

SAPROSITES STERNALIS, Blackb.

I obtained in the Cairns district two specimens that possibly belong to this species (the type of which is in the British Museum); they agree with the description and with the position assigned to the species in Blackburn's table, except that they have a few punctures on the metasternum but normally concealed by the middle legs, and that they are black (with red legs), instead of red; but as *S. mansuetus*, *S. mendax* and *S. nitidicollis* all have black (or blackish) and reddish forms, it is probably that *S. sternalis* similarly varies.

SAPROSITES MESOSTERNALIS, sp. nov.

Black, highly polished, legs dark castaneous, antennae and palpi paler.

Head wide and strongly convex, margins narrow but dilated near eyes (these partly visible from above); with numerous small but rather sharply defined punctures, but becoming indistinct near apical emargination. Prothorax about once and one-half as wide as long, margins rather narrow, hind angles rounded off; with numerous rather large, irregularly distributed punctures, and many very small ones. Elytra about twice the length of prothorax; regularly striate-punctate, interstices impunctate; shoulders dentiform. Mesosternum with intercoxal process narrow, then dilated and deflected, and then largely dilated and convex, with punctures only on its sides. Legs rather short and stout; front tibiae acutely tridentate externally. Length, 3¾—4¼ mm.

Hab.—Lord Howe Island (A. M. Lea).

The mesosternum is on the same plane as the metasternum only so far as the intercoxal process is concerned, the front part largely bulges out and encroaches upon the prosternum (much as in *S. nitidicollis* and *S. mansuetus*), the convex portion being about as large as one of the front femora. In Blackburn's table it would be associated with *mansuetus*, from which it differs in being considerably larger (it is larger than any species previously recorded from Australia) and with different prothoracic margins and and punctures; the large prothoracic punctures are absent from the sides, and from about the apical fourth, where the small ones are rather dense. The majority of the specimens before me are black or almost so, but one is of a rather dark castaneous, and others have the front of the

1. Blackburn, Proc. Roy. Soc. Vic., 1904, pp. 175, 177, 178.

head obscurely diluted with red. Six specimens were obtained on the island (mostly on Kentias), and two were reared from Kentia stems brought to Adelaide; there are three in the Australian Museum, one labelled as from Mount Ledgbird.

SAPROSITES CASTANEUS, sp. nov.

Dark castaneous and highly polished, appendages somewhat paler.

Head wide and strongly convex, margins narrow but suddenly triangularly dilated near eyes (these partially visible from above); punctures rather numerous and small but sharply defined, becoming more numerous but less distinct in front. Prothorax about once and one-half as wide as long, margins rather narrow, hind angles almost rectangular; with moderately large punctures and many of smaller size. Elytra strongly striate-punctate, interstices impunctate. Mesosternum narrow between coxae and thence almost evenly dilated to apex; without discal punctures. Legs rather stout; from tibiae strongly tridentate externally. Length, 2¾—3 mm.

Hab.—Lord Howe Island (A. M. Lea).

The mesosternum between the coxae is rather narrow and convex, but dilates evenly forward, somewhat as in *S. mendax*, but the species is considerably smaller than *mendax* (or any other species tabled by Blackburn) and the basal angles of the prothorax are almost rectangular; the punctures in the elytral striae are larger and the interstices are narrower than in *mendax*, *S. mansuetus* or *S. nitidicollis*. From the preceding species it is readily distinguished by its much smaller size and very different punctures. The larger punctures on the pronotum are numerous but irregularly distributed, and become smaller towards the apex; there are also many small punctures scattered about, but becoming rather dense towards the apex. Six specimens were obtained.

SAPROSITES CLYPEALIS, sp. nov.

Dark castaneous-brown, antennae palpi and legs reddish.

Head with dense and rather small but sharply defined punctures, becoming granulate in front; apex widely and rather shallowly notched. Prothorax almost twice as wide as long, sides moderately rounded, front angles feebly produced, hind ones rounded off, sides and base finely margined, a shallow depression near each front angle; punctures about apex much as on base of head, but becoming larger elsewhere. Elytra parallel-sided to near apex, shoulders very feebly armed; striate-punctate, interstices much wider than striae, not separately convex, crenulate internally, each with one or two irregular rows of small punctures, on apical slope becoming narrower, separately convex and with stronger punctures. Metasternum with a narrow, deep median stria, with rather small but distinct punctures scattered about and becoming denser on sides. Mesosternum with a wide intercoxal process, with a narrow, shining, median carina. Length, 3 mm.

Hab.—Queensland: Cairns (E. Allen).

The hind angles of prothorax rounded off distinguish the species from *S. mendax*, the elytral interstices are also wide, and with more distinct punctures, and those in the striae are much smaller; *S. mansuetus* and *S. nitidicollis* which have somewhat similar hind angles, have elytral interstices narrower and with less distinct punctures, and the striae deeper with much larger punctures; the punctate metasternum distinguishes from the description of *S. sternalis*.

SAPROSITES PYGIDIALIS, sp. nov.

Opaque brownish-red, antennae and palpi paler.

Head wide, with crowded and rather small but mostly asperate punctures; clypeal suture rather feeble in middle but distinct elsewhere; front rather shallowly incurved to middle. Prothorax twice as wide as long, sides widely margined except near base, where the hind angles are oblique, front angles feebly produced; with crowded and fairly large, but rather shallow punctures, becoming smaller in front. Elytra parallel-sided to near apex, about the width of head and much narrower than prothorax, each shoulder with a small but rather acute tooth; punctate-striate, punctures rather large but not very conspicuous, interstices separately convex, wider than striae and with small punctures, becoming narrower posteriorly, but even there slightly wider than striae. Metasternum with a subelliptic median depression containing a narrow median stria; with dense and sharply defined punctures, becoming crowded and asperate on sides. Mesosternum with intercoxal process very wide, in front semicircularly impressed, from the impression a narrow carina directed backwards to middle, and then bifurcated to base. Abdomen with rather coarse punctures; pygidium with two distinct cavities separated by a median carina. Femora densely punctate, grooved for partial reception of tibiae. Length, 4.5 mm.

Hab.—New South Wales: Tamworth (A. M. Lea).

By Blackburn's generic table this species could only be referred to *Saprosites* or to a new genus, and although its opaque derm with wide prothoracic margins cause it to differ considerably in appearance from all other Australian species of *Saprosites*, it may, for the present, be referred to it; from *Euparia* it differs in the mesosternum being almost on the same plane as the metasternum. With the head in its normal position the eyes are almost entirely concealed, both from above and below.

EUPARIA SQUAMOSA, sp. nov.

Black, opaque; palpi and parts of legs more or less castaneous, antennae flavous. Densely clothed with more or less muddy-brown scales.

Head wide, apex very feebly incurved to middle, sides suddenly and strongly narrowed towards base; with crowded and rather coarse but more or less concealed punctures. Eyes small, narrow and finely faceted, not visible from above. Prothorax about once and

one-fourth as wide as long, margins widely explanate, but suddenly narrowed towards and terminated before base, front angles obtusely produced; with several feeble discal impressions; punctures crowded and irregular but more or less concealed; with an irregular median carina. Elytra with large more or less concealed punctures; interstices very irregular. Mesosternum wide between coxae, dilated and depressed to apex, finely granulate, with a narrow median carina. Metasternum with a narrow groove along middle, where the length is considerably less than that of the mesosternum; with crowded punctures. Abdomen with crowded punctures. Front femora stout, strongly inflated near middle, middle pair moderately stout, the others thinner; front tibiae strongly tridentate at and near apex, the others moderately long, rather thin and curved but dilated at apex, hind pair with two unequal spines at apex; basal joint of hind tarsi almost the length of the following ones combined, and more than one third the length of the tibiae. Length, 5—5.25 mm.

Hab.—Lord Howe Island (A. M. Lea).

"The dorsal surface of elytra having a basal edging" regarded by Blackburn as an important generic character in the *Aphodiides* is certainly a rather unsatisfactory one to use, as the basal edging is usually concealed when the elytra are closely applied to the prothorax. Specimens of the present species do not appear to have a basal edging unless the elytra are forced aside from the prothorax, when a feeble and interrupted one becomes visible; the widely separated middle coxae would, regarding the species as belonging to B of this table[2], associate the species with *Proctammodes*, with which it has scarcely anything else in common; but regarding it as belonging to BB, the strongly flattened prothoracic margins would associate it with *Euparia;* with which it would also be associated in Leconte's table[3], it is therefore referred to that genus, although with considerable doubt, as probably a new one should have been proposed for it; certainly it doesn't look at all close to any of the species of *Euparia* figured by Schmidt[4] From *E. olliffi* (the only species previously recorded from Australia) it is at once distinguished by its dense clothing and tuberculate elytra. The widest part of the prothoracic flange is near the apex, where it is rather more than one-third the width from the side to the middle; the base of the pronotum as seen obliquely from in front appears to be in six obtuse lobes; the elytral interstices are irregularly broken up so as to resemble flattened tubercles, but posteriorly the tubercles are larger, more pronounced and longitudinally distant from each other, the sutural interstice is almost regular throughout, but all the others are very irregular; the medio-apical portion of the head is glabrous, and has much smaller punctures than elsewhere. Seven specimens were obtained from fallen leaves, and most of them are so encrusted with mud (which cannot be removed without removing many of the scales also) that the punctures (and

2. Blackburn, Proc. Roy. Soc. Vic., 19 '4, p. 150.
3. Leconte, Class. Col. N. Am., part I., p. 127.
4. Schmidt, Wytsman's Gen. Insect, fasc. 110. p' pl. II.

finer sculpture generally) are more or less concealed; the scutellum is generally covered with mud, but on two specimens is seen to be small, narrow and shining.

In Arrow's table of certain families of *Scarabaeidae* (Trans. Ent. Soc. Lond., 1909, p. 485), one of the characters used for separating the *Aphodiides* from the *Coprides* was the "mid-coxae contiguous" of the former; but in *Proctammodes*, *Ataenius*, *Saprus*, *Saprosites* and *Psammodius*, they are conspicuously and usually widely separated.

PSAMMODIUS RUGICOLLIS, Macl. (*Ammoecius.*)

P. australicus, Blackb.

Ammoecius rugicollis of Macleay is a *Psammodius*, and the species subsequently named *P. australicus* by Blackburn.

PSAMMODIUS LITORALIS, sp. nov.

Bright reddish-castaneous, antennae paler, parts of legs infuscated.

Head closely covered with large granules, except at base and on sides of clypeus; front rather deeply notched. Prothorax strongly convex, almost twice as wide as long, sides moderately rounded, front angles obtusely produced, hind ones rounded off, sides and base distinctly margined; with fairly large punctures, transversely conjoined to form a groove near apex, but interrupted in middle, another groove across middle, interrupted in middle and terminated before sides, a few punctures conjoined to form a short median line, and a few irregularly distributed. Elytra with sides feebly dilated to beyond the middle; punctate-striate, interstices separately convex and much wider than striae, but about the same width on apical slope. Metasternum with a deep median line and a few scattered punctures. Length, 2.75 mm.

Hab.—New South Wales: Gosford, on sea-beach (H. J. Carter).

Allied to *P. rugicollis* and *P. pachypus* but at once distinguished by the prothoracic punctures; in addition to those forming grooves on the type there are about six free ones, on a second specimen the grooves are much the same, but there are more free ones.

PSAMMODIUS PACHYPUS, sp. nov.

Castaneous and shining, legs and antennae paler, discs of head and of prothorax somewhat infuscated.

Head rather wide and convex, margins rather narrow, suddenly terminated at eyes (these distinct from above); basal third with small punctures, elsewhere conspicuously granulate. Prothorax about once and one-half as wide as the median length and about twice that of the sides; margins very narrow, hind angles strongly rounded; with coarse, irregularly distributed punctures and some small ones. Elytra strongly punctate-striate, punctures in striae rather narrow.

Legs very short and stout; basal joint of hind tarsi much shorter than apical width of tibiae. Length, 2¾ mm.

Hab.—Lord Howe Island (A. M. Lea).

Smaller than any of the species tabled by Blackburn, but in his table would be associated with *P. obscurus*, from which it also differs in being more brightly coloured, punctures of upper-surface smaller, and margins of prothorax not quite the same. There are no regular sulci on the pronotum, but near the apex there is a narrow impression on each side (not traceable across the middle) that appears to be made of conjoined punctures, there is also a vague longitudinal medio-basal impression containing punctures.

RHYSSEMUS RHIZOPHAGUS, sp. nov.

Black, front of head and of prothorax very narrowly, antennae palpi and tarsi more or less obscurely reddish. Prothorax at base and sides fringed with short, stout setae.

Head rather closely covered with conspicuous granules, several shallow depressions at base, front moderately incurved to middle. Prothorax about three-fifths as wide as long, sides feebly rounded and crenulated, front agnles slightly produced, hind ones obtuse, a deep transverse submedian impression terminated some distance from sides, a fairly deep impression near sides in front, becoming shallower and dividing into two parts across middle, near base with two very feeble transverse impressions, closed near middle by the sides of a deep median impression, which becomes shallower and disappears before apex; surface closely covered with granules and punctures. Elytra subparallel-sided to near apex; interstices appearing as closely placed rows of small granules. Metasternum shining in middle, near middle coxae granulate-punctate, elsewhere opaque and densely asperate-punctate. Length, 3—4 mm.

Hab.—Western Australia: Swan River, noted as eating roots of couch grass (J. Clark), Bunbury (R. Helms and A. M. Lea), Vasse River, in flood debris (Lea).

Owing to transverse impressions the prothorax is traversed by four irregularly granulated ridges, of which only the one before the submedian groove is at all well defined; the one behind that groove is interrupted at the middle, with its inner ends curved backwards so as to close the feeble subbasal grooves. The elytral interstices are broken up into rows of granules, those on the even interstices are smaller and more distantly placed than on the others, the odd interstices are more elevated than the even ones, and the fifth and ninth more than the others, with the intervals between the granules more distant so that they appear more as interrupted costae. The legs, as a rule, are not as dark as the rest of the body, but, except for the tarsi, they are seldom distinctly reddish; the tip of the abdomen is usually obscurely diluted with red. One small specimen is entirely of a pale, dingy reddish-brown, two others have the elytra dark reddish-brown, but most of the specimens are deep black, with the elevated parts shining and the depressed parts opaque.

RHYSSEMUS INSIGNICOLLIS, sp. nov.

Piceous-brown or blackish, head (partly or entirely), legs and tip of abdomen reddish. Prothorax with a fringe of stiff short setae at base and sides.

Head with dense and well-defined granules, near base with several oblique impressions; base itself with dense punctures; front rather widely notched. Prothorax about four-fifths as long as wide, sides gently rounded, front angles slightly produced, hind ones rounded off; with several transverse, opaque depressions, separated by smooth, shining ridges, but surface more or less granulate about sides. Elytra parallel-sided to near apex, shoulders feebly armed; striae narrow and deep; interstices punctate-granulate, the suture smooth throughout. Metasternum with a deep median stria which is dilated posteriorly, the sides opaque and granulate-punctate. Length, 3—3.25 mm.

Hab.—Queensland: Cairns district (C. J. Wild and Blackburn's collection), Townsville (F. P. Dodd), Thursday Island (N. B. Tindale).

Two specimens are almost black. Of the transverse ridges on the prothorax the first is feeble and subapical, the second and third are continuous across middle and terminate some distance from the sides, the fourth is interrupted in the middle, with its inner ends turned backwards so as to close the subbasal impressions, and the fifth and sixth are close together, subbasal and not much more distinct than the first; there are, therefore, three very conspicuous ridges and three less conspicuous ones.

RHYPARUS, Westwood, Trans. Ent. Soc. Lond., IV., p. 240.

This genus, distinct by six longitudinal ridges on the prothorax, and widely distributed in the Malay Archipelago, can now be recorded as Australian.

RHYPARUS AUSTRALIAE, sp. nov.

Black or blackish, legs obscurely reddish, antennae and palpi paler.

Head with four longitudinal ridges, the median ones interrupted in middle and terminated before apex, the outer ones also interrupted in middle and then obliquely directed to sides; base with crowded but not sharply defined punctures, sides in front of eyes dilated and concave, then somewhat sinuous to apex, which is truncated. Prothorax not much wider than long; with six narrow, longitudinal ridges, the median pair closer together on apical half than on basal half, the outer pair sinuous, the intermediate pair interrupted in a transverse depression near apical third; each margin with a narrow ridge deeply notched at apical third, between it and the outer discal ridge a shorter obtuse ridge, and remnants of other ridges near apex; some fairly large but shallow punctures along middle and a few elsewhere. Elytra about as wide as prothorax, sides feebly

dilated near base; with rows of large subquadrate punctures, odd interstices distinctly elevated above their fellows, the third, fifth and seventh rather abruptly terminated just below summit of apical slope, the ninth curved round and considerably thickened or subtuberculate near suture; between it and apex with larger punctures than elsewhere. Prosternum with two large excavations in front, between them a strong projection, another but smaller and more acute in middle of base. Metasternum with a deep and rather wide median excavation, an irregular excavation behind each middle coxa; with fairly large punctures. Abdomen with most of the segments ridged posteriorly, and at base with a row of very large punctures, apical segment with a narrow longitudinal ridge continued on to pygidium, where it separates small areolets. Front tibiae at apex with two small teeth and an inner spur. Length, 4—4.5 mm.

Hab.—Queensland: Cairns district (F. P. Dodd and A. M. Lea).

The head when at rest is almost vertical, with the large eyes entirely concealed and apparently with six small subtriangular tubercles almost in line with the prothoracic ridges. The elevated parts of the upper-surface have extremely short pale setae (scarcely visible under a magnifying glass), on the under-surface there are also very short setae, on the legs the clothing is more distinct.

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. I., 1923].

ART II.—*Acceleration of Gravity at the Melbourne Observatory; Supplementary Note.*

By E. F. J. LOVE, M.A., D.Sc., F.R.A.S.

Read 14th June, 1923.

The present note is a necessary supplement to my paper of last year on Gravity Determinations in Australia, as the subsequent appearance of Wright's[2] memoir has reopened the question as to the most probable value of g for Melbourne.

Wright employed three of the five pendulums previously swung in Melbourne by Hecker, and also made use of the same coincidence clock as that observer. In view of the facts that (a) Wright carried out 18 sets of observations as against Hecker's 30 sets (b) the coincidence clock kept much the steadier daily rate during Hecker's observations (c) Wright's measures show, on analysis, a small but well-marked diurnal variation, differing in character for the different pendulums, it seems reasonable to assign to Wright's determination half the weight of Hecker's. Combining this estimate with those utilised in my previous paper, the table of results for Melbourne is as follows: —

TABLE.

Observer.	Value of g.	Weight.	Difference from Weighted Mean.
Baracchi-Love	979 977	0·5	— ·011
Muller v. Elblein	·991	1·0	+ ·003
Guberth	·997	1 0	+ ·009
Hecker	·985	2·0	— ·003
Alessio	·985	1 5	— ·003
Wright	:991	1·0	+ ·003
		Weighted mean:	979·988
		Mean error:	± ·0023.

Hence we have for Melbourne Observatory

$$g \quad = 979\cdot988 \pm \cdot002 \text{ cm. sec}^{-2};$$

which becomes, on reduction to sea-level,

$$g \quad = 979\cdot996 \text{ cm sec.}^{-2},$$

and after applying Bouguer's correction

$$g_0'' \quad = 979\cdot993 \text{ cm sec}^{-2}.$$

In view of the considerable variations, progressive and temporary, shown by the papers of the Potsdam observers, to have occurred in the periods of the pendulums employed, the differences between the results of Wright, Hecker and Alessio, both for Melbourne and Sydney, are nearly of the order of the instrumental uncertainties; Wright's suggestion that they may be due to actual variations of gravity seems unnecessary.

1. Love, P.R.S. Vict., xxxv. (N.S.), p. 90.
2. C. S. Wright, Determinations of Gravity, British (Terra Nova) Antarctic Expedition.

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. I., 1923].

ART. III.—*A Revision and Description of the Australian Tertiary Patellidae, Patelloididae, Cocculinidae, and Fissurellidae.*

By FREDERICK CHAPMAN, A.L.S.,

AND

CHARLES J. GABRIEL.

(With Plates I.-III.)

Read 12th July, 1923.

Introduction.

There has been considerable confusion in the past regarding the specific and even generic standing amongst one of our commonest groups of Australian Tertiary Mollusca, viz., the patelloid and emarginuloid forms. The present work has been undertaken with a view to clearing up some of these difficulties.

We have had the special advantage of handling the principal collections containing these forms and which comprise the National Museum collections (Dennant coll., Mulder coll., and Sweet coll.), as well as the private collections of Messrs. F. A. Cudmore (including part of the T.S. Hall coll.), F. A. Singleton, W. J. Parr, Miss Crespin, and F. Chapman. We have, therefore, critically examined probably more than a thousand specimens. Our thanks are due to Messrs. Cudmore and Singleton for the loan of their specimens, and in cases where specified, for the donation of selected types; whilst Miss I. Crespin, B.A., has kindly assisted us in regard to the fauna of Green Gully, Keilor.

An especial feature of this descriptive work was the comparison between the fossil and living faunas, in which the persistent life-history of the specific forms were clearly seen, and in some cases ranging from Oligocene times, at the most, with only slight morphological variations.

In regard to one of the most difficult questions arising from insufficient description, that of the actual identity of *Emarginula transenna*, T. Woods, we are under great obligations to Mr. W. L. May, of Forest Hill, Sandford, Tasmania, who lent us specimens for comparison, and to the Curator of the Tasmanian Museum, Hobart, Mr. Clive E. Lord, F.L.S., who kindly allowed us to see the Johnston Homoeotype.

Systematic Descriptions.

Fam. PATELLIDAE.

Genus ellana. Adams, 1869.

CELLANA CUDMOREI, sp. nov. (Plate I., fig. 1; pl. III., figs. 27, 28.)

Description.—Shell large, elevated, oval, rather strongly built; apex situated about one-third from the anterior margin. Sculpture consisting of numerous strong riblets, with two or three smaller ones occupying the interspaces. Growth-lines undulate, fine, not well developed. Interior of shell having the convexity of the external riblets indicated by deep grooves, which are crossed by fine lines of growth. These radial grooves of the interior may possibly have become more distinctly engraven on account of a certain amount of dissolution of the shell, especially the nacreous layer of the interior, and owing to its peculiar preservation in the polyzoal limestone matrix.

Dimensions.—Length, 40 mm. Greatest width, 30 mm. Height, circ., 10 mm. Width of coarser riblets at margin of shell, circ., 1·75 mm. About three of the strong riblets go to 10 mm. on the anterior margin, as in a full grown living specimen of the limpet, *Cellana variegata*, Blainville sp. (*Patella tramoserica* of authors).

Observations.—The above species appears to be the ancestral form of *Cellana variegata*, Blainv. sp. It differs, however, in having a more depressed and narrower shell.

Occurrence.—Holotype. From the Miocene (Janjukian) polyzoal rock of Batesford, near Geelong. The type was found by Mr. F. A. Cudmore, after whom the species is named, and who has presented the specimen to the National Museum.

CELLANA HENTYI, sp. nov. (Plate I., fig. 2.)

Description.—Shell of medium size, elevated, narrowly oval, apex a little in front of the centre. In the present state of fossilisation the apex is denuded of ornament. Surface ornament consisting of moderately strong radiating ribs, with several intermediate, less pronounced riblets; these are crossed by growth-lines which are strongly undulate and which are produced at the intersections into nodulose growths. Shell still retaining its natural colour, from olive green to black.

Dimensions.—Length, 20 mm. Width, 14·5 mm. Height, 10·5 mm.

Observations.—This species is more elevated and longitudinally compressed than the living *Patella squamifera*, Reeve[1], but in some respects the ornament agrees in having the radii produced into nodulous outgrowths, though not to so marked a degree. On the other hand comparison may be made with the recent *Cellana variegata*, Blainville, sp.[2], especially in the height of the shell and the

1.—Conch. Icon., vol. VIII. 1855, pl. XXXII. fig 94. Hedley, Austral-Antarctic Exped., Mollusca, 1916, p. 43, fig. 2.

2.—*Patella variegata*, Blainville, Dict. Sci., Nat., vol. XXXVIII. 1825. p. 10. *Cellana variegata* Blainville, sp., Hedley Proc. Linn. Soc., N.S.Wales, vol. XXXIX. 1915, p. 714.

character of the ribs, which are not so squamose as in the above quoted species.

Named in honour of Mr. Archie Campbell Henty, from whom the authors had much kindly assistance in collecting at this locality.

Occurrence.—Holotype. Lower Pliocene (Kalimnan) shell bed at Forsyth's, Grange Burn, near Hamilton. Type found by F. Chapman and presented to the National Museum.

Fam. PATELLOIDIDAE.

Genus PATELLOIDA, Quoy and Gaimard, 1834.

PATELLOIDA HAMILTONENSIS, sp. nov. (Plate I., fig. 3.)

Description.—Shell solid, irregularly oval, strongly ribbed; apex sub-central, much eroded and probably originally smooth. The sculpture consisting of about ten rather prominent radiat ng ribs, the interspaces of which are occupied by finer riblets of varying strength. About three irregular growth stages are discernible on the shell surface, which are marked by slight overlapping or sulcation. The area between the major ribs, depressed or fluted, resulting in an undulose margin to the shell. Colour, pale ochre.

Dimensions.—Length, 13 mm. Width, 12 mm. Height, 5·5 mm.

Observations.—This species approaches *Patelloida perplexa*, Pilsbry[3], but differs in the ribs being less pronounced and not salient at the margins.

Occurrence.—Lower Pliocene (Kalimnan). Holotype and two others; Dennant coll., Muddy Creek, upper beds (probably MacDonald's). Another example, presented by the late J. H. Young, 13/5/'13.

PATELLOIDA MULTIRADIALIS, sp. nov. (Plate I., fig 4; pl. III., fig 29.)

Description.—Shell of median size, thin, roundly oval, depressed conical; apex almost central. Surface ornamented with ribs exceeding 100; some of these are intermediate and smaller than the main ribs. Growth lines rather obscure but producing a tegulate appearance on crossing the ribs. In the apical area the riblets are beaded in character, but towards the margin the ornament appears as overlapping scales. Interior polished, margin crenulated, with hollow sulci.

Dimensions.—Length, 14·5 mm. Width, 12·5 mm. Height, 5·25 mm.

Observations.—In some points this species resembles the living *P. calamus*, Crosse and Fischer, sp.[4], of Port Phillip and Western Port, but differs in the more depressed form of shell, its rounder outline and the more scaly character of the ribs.

3.—*Acmaea saccharina*, var. *perplexa*, Pilsbry, Man. Conch., vol. XIII.., 1891, p. 50, pl. XXXVI, figs. 69-71.

4.—*Patella calamus*, Crosse and Fischer, 1864, Journ. de Conch., p. 348. *Id.*, *ibid.*, 1865, p. 42, pl. III., figs. 7, 3.

Occurrence.—This species is represented by a unique specimen, from the Balcombian (Oligocene), towards the upper part of the Clifton Bank. Type presented to National Museum by F. Chapman.

PATELLOIDA PERPLEXA, Pilsbry, sp.

Patella octoradiata, Hutton, 1873 (non Gmelin 1791), Cat. Marine Moll. New Zealand, p. 44, No. 201.

Acmaea saccharina, var. *perplexa*, *Pilsbry*, 1891, Man. Conch., vol. XIII., p. 50, pl. XXXVI., figs. 69-71.

Patella perplexa, Pilsbry, Pritchard and Gatliff, 1903, Proc. Roy. Soc. Vic., Vol. XV. (N.S.), pt. 1, p. 194.

Acmaea octoradiata, Hutton, sp., Hedley, 1904, Proc. Linn. Soc. N.S.Wales, vol. XXIX, pt. I., No. 113, p. 188. Pritchard and Gatliff, 1905, Proc. Roy. Soc. Vict., vol. XVIII. (N.S.), p. 65. Verco, 1906, Trans. Roy. Soc. S. Australia, vol. XXX., p. 209. Chapman, 1912, Proc. Roy. Soc. Vict., vol. XXV., pt. I., p. 186, pl. XII., figs. 1, 2. Suter, 1913, Man., N.Z., Moll., p. 75, pl. VII., fig. 6.

Patelloida perplexa, Pilsbry, sp. Iredale, 1915, Trans. N.Z. Inst., vol. XLVII., p. 430.

Observations:—S nce writing the account of the first fossil occurrence of the above species by one of us (F.C.) a new locality besides that of Flemington has been found by Miss I. Crespin, B.A., at Green Gully, Keilor. The examples there found are also in the form of casts, but the moulds show the style of ornament and its variational tendency as with the recent forms, and wax squeezes of the moulds give a good idea of the fine radial ornament.

Occurrence.—Janjukian (Miocene). Flemington Railway cutting, ironstone beds (J. S. Green coll.). Green Gully, Keilor, in ironstone (Miss I. Crespin coll.).

Fam. COCCULINIDAE.

GENUS Cocculina, Dall., 1882.

COCCULINA PRAECOMPRESSA, sp. nov. (Plate I., figs. 5, 6, 7, 8.)

Description.—Shell small, laterally compressed, narrowly ovate, elevated; apex distinct, reverted anteriorly and slightly eccentric. Sculpture consisting of fine growth-lines. Apex white, the remainder of shell being ivory yellow.

Dimensions.—Length, 3·75 mm. Width, 2 mm. Height, 2·5 mm.

Observations.—The present species shows some closely comparative features with the living *C. compressa*, Suter[5], especially in the compressed outline and in the height of the shell. The apex of the present species, however, is more prominent and salient, and the

5.—Suter, H., Proc. Malac. Soc., vol. VIII., 1908, p. 27, pl. II., figs. 17, 18. Idem. Manual of New Zealand Mollusca, 1913, p. 174, pl. XXXIV., figs. 14, 14*a*.

anterior slope is more convex, the posterior being more concave. The other example we figure from Shelford (Pl. I., figs. 5, 7, 8) is a broader form, which at present we are inclined to regard as a local variation.

Occurrence.—Balcombian (Oligocene); from the older beds at Muddy Creek. This Holotype was presented to the National Museum by Mr. J. H. Young. Also from beds of the same age in the same locality, in Dennant and Cudmore colls. From Balcombe Bay, Port Phillip, coll. by W. Kershaw (Nat. Mus.); Janjukian (Miocene); Shelford, Dennant coll.

COCCULINA GUNYOUNGENSIS, sp. nov. (Plate I., figs. 9, 10.)

Description.—Shell comparatively large, roundly oval, capuloid, fairly high; apex subcentral and prominent with a slight twist to the right anterior. Surface generally slightly convex, excepting at posterior slope, where it is depressed or even concave. Shell nearly smooth, but with fine growth-lines crossed by excessively fine radii.

Dimensions.—Length, 9 mm. Width, 7·5 mm. Height 5·5 mm.

Observations.—The present species in some respects approaches *Addisonia lateralis*, *Requien*, sp.,[6] but that it is more convex, with the growth-lines more pronounced. In view of the fact that the apex of our shell is asymmetrical, the new species may have to be placed in the genus *Addisonia.*

Occurrence.—Holotype from Balcombian beds (Oligocene); Grice's Creek (formerly Gunyoung Creek), Port Phillip. Also of same age from Balcombe Bay (W. Kershaw coll.); Muddy Creek, older beds (Dennant coll.).

Fam. FISSURELLIDAE.

Genus Emarginula, Lamarck, 1801.

Synopsis of the Genus *Emarginula*:

Name.	Altitude.	Outline.	Costae.	Slit fasciole.	Base.
E. wannonensis, Harris	High	Broadly ovate	Nodulose	Costate	Laterally concave
E. transenna, T. Woods	High	Broadly ovate	Latticed	Costate	Flat
E. maudensis, Chapm. & Gabr.	Low	Elongate-ovate	Few; nodulose	Costate	Flat
E. dennanti, Ch. & Gab.	Low	Elongate-ovate	Numerous; undulose-tegulate	Sulcate	Flat
E. delicatissima, Ch. & Gabr.	Low	Elongate-ovate	Numerous; fine and horizontally cancellate	Sulcate	Flat

EMARGINULA DELICATISSIMA, sp. nov. (Plate I., figs. 11, 12; pl. III., figs. 30, 31.)

Description.—Shell elongate-ovate, depressed, slightly narrower anteriorly; apex recurved and close to anterior margin. Posterior

6.—*Gadinia lateralis*, Requien, Coq. de Corse, 1848, p. 39. *Addisonia lateralis*, Req. sp., Pilsbry, Man. Conch, vol. XII., 1899, p. 139, pl. xxv. figs. 26, 27.

region flattened towards margin, the remainder generally convex. Sculpture: ornamented with a series of rounded radial ribs, crossed by delicate concentric threads producing a fine cancellation; between main, ribs one or more fine secondary ribs. Slit-fasciole situated between two sharp ridges and filled in with a concentrically layered callus. This fasciole is represented in the interior of shell by a well-marked groove, bounded by rounded ridges. Internal margin of shell marked by a denticulated border, the serrations of which are more or less truncated.

Dimensions.—Length, 10·5 mm. Width, 6 mm. Height, 5·25 mm. Length of slit, 3·5 mm.

Observations.—This is the most finely sculptured form of our Australian Tertiary species of the genus.

Occurrence.—Balcombian (Oligocene); type from Balcombe Bay, (Dennant coll.); Table Cape, Tasmania, Gellibrand River and Inver-the lower beds at Muddy Creek.

Janjukian (Miocene); Shelford, Mitchell River and Torquay, Dennant coll.; Table Cape, Tasmania, Gellibrand River and Inverleigh (F. A. Cudmore and W. L. May coll.); Fyansford (F. A. Singleton coll.); in ironstone, Lake Mundi, Casterton (Coll. Z. Neall).

EMARGINULA DENNANTI, sp. nov. (Plate I., figs. 13, 14; pl. III., fig. 32.)

Description.—Shell large, fragile, ovately-conical, moderately high; apex comparatively small, strongly recurved, situated about one-third from posterior margin. Surface of shell strongly convex anteriorly, moderately convex posteriorly. Sculpture consisting of about 24 well-defined, radiating ribs, between which are secondary riblets, and between these again a fainter tertiary series. Concentric ridges undulating and lamellose, and where they cross the radials, a tegulate appearance is produced. Slit-fasciole situated between two sharp ridges; callus formed of distinct concave lamellae. Inner margin of shell bluntly denticulated. Slit-fasciole interiorly marked by a fine groove with swollen margins.

Dimensions.—Length, 20·5 mm. Width, 14·75 mm. Height, 9·75 mm. Length of slit, 5·25 mm.

Observations.—The concentric lamellose character and the tegulation of the ribs make this species easily identifiable from other related forms.

This species was tentatively named by J. Dennant in his collection as "aff. *transenna*," from which it differs in its longer shell and more central apex.

Occurrence.—Balcombian (Oligocene); type from Grice's Creek, (J. F. Bailey coll.) Also from Altona Bay Coal Shaft, Balcombe Bay and Muddy Creek, (Cudmore coll.); Muddy Creek, (Dennant coll.).

Janjukian (Miocene); Gellibrand River, (Cudmore and Parr colls.) An internal cast of a related, if not identical, shell occurs in the Murray Cliffs at Morgan (F. A. Cudmore coll.).

EMARGINULA MAUDENSIS, sp. nov. (Plate II., fig. 15; pl. III., fig. 33.)

Description.—Shell small, elongate-ovate, of medium height. Apex situated close to the posterior. General surface convex anteriorly, depressed posteriorly. Ornament consisting of about 16 prominent radial ribs which are crossed in concentric lines, forming at the intersection of the ribs a strong beaded character. Slit fasciole filled in with a beaded callus, the slit situated between two sharp ridges.

Dimensions.—Length, 4·5 mm. Width, 2·75 mm. Height, 2·75 mm. Length of slit, 1 mm.

Observations.—The above species appears to be the smallest Victorian Tertiary form. In the style of ornament it suggests a juvenile form of *E. wannonensis*, Harris, but differs in having a more elongate and depressed shape, in the more posterior position of the apex and in its fewer ribs.

Occurrence.—Janjukian (M'ocene); Maude, (Dennant coll.).

EMARGINULA TRANSENNA, T. Woods. Plate II., figs. 16, 17.)

Emarginula transenna, T. Woods, 1877, Proc. Roy. Soc. Tas. (for 1876), p. 163. Pritchard, 1896, Proc. Roy. Soc. Vict., vol. VIII. (N.S.), p. 147. Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., vol. I., pt. 2, p. 117. May, 1919, Proc. Roy. Soc. Tas. (for 1918), p. 70, pl. VIII., fig. 1. Id., 1919, ibid., p. 107.

Observations.—The above species has given us not a little trouble in deciding its relationship to many of the commonest forms of this type in Victoria. We have now had the advantage of examining and comparing Topotypes, one from the Hobart Museum (Johnson coll.) and another from Mr. May's private collection, the former having been figured by May in his 1919 paper. We are now satisfied that the so-called "Johnston co-type" figured by May, which of course is merely a topotype, represents a much abraded example of the species. The figure appears to us to suggest a cap or callus on the apex, but it seems that this appearance is due rather to the wearing down of the shell to the subexternal layer. On examining the Johnstonian specimen we find that the slit-fasciole has an abnormally rib-like character, which is really due to the wearing away of the lateral laminae, leaving the intermediate fasciole infilling as a smooth, prominent ridge.

The largest specimen we have met with is from Bird Rock Cliffs (F. A. Cudmore coll.), which has a longer diameter of 21 mm.

Original Description of Tenison Woods:—

"Shell thick, small, oblong, subquadrate posteriorly, end slightly produced, conical, high, apex submarginal, smooth, acute, recurved, parallel with the margin, anterior surface ventricose, posterior concave, latticed; radiating ribs 23, high, between them smaller ones, which often in descending give rise to still smaller; transverse ribs raised, but always more sunken than the radiate, and at all the points

of intersection, very projecting granules, interstices very deep and square, fissure slightly longer than width, margin denticulate, straight. Long. 11, Lat. 6, Alt. 6. Fissure, Long, 1¼ mill., Lat. ½ mill."

Relationships and Distribution.—In the view that this species is perhaps the commonest of the Victorian emarginulids, one can gain a better idea of the variation of morphological groups both as to time and space. In the Balcombian, which is typically of fairly deep water phase, *E. transenna* is usually represented in these beds as a thinner and more delicately ornamented form, as compared with the Table Cape type form, which, as an element of the fauna of the "Crassatellites Bed," indicates that the conditions at that locality were fairly shallow water in character. At Corio Bay and Gellibrand, also of Janjukian-age, but of deeper water conditions than at Table Cape and more muddy in character, we find the form to tend towards the thinner shelled variations.

In the species described by Harris[7] as *E. wannonensis*, we seem to have a parallel form with the above, but very closely related. The distinctive characters which can there be distinguished are seen in the very stout build of the shell and the super-ventricose anterior, the stronger ornament and the typically concave margin in the median border of the shell. Another distinction is seen in the discrepant growth stages of the shell, which indicate distinct periods of rest. The slit-fasciole is not remarkably differentiated from the rest of the main ribs, as is the case with *E. transenna*.

Occurrence.—In the Balcombian (Oligocene Series), from the Lower Beds at Muddy Creek; Balcombe Bay, Grice's Creek and Altona Bay coal shaft, Port Phillip; in the Janjukian (Miocene Series), from Table Cape, Tasmania (T. Woods and F. A. Cudmore); Green Gully, Keilor (G. Sweet and I. Crespin colls.); Murgheboluc (F. A. Cudmore, T. S. Hall and F. Chapman coll.); Gellibrand; Fyansford; Corio Bay (F. A. Singleton and F. Chapman coll.); Western Beach, Geelong (Dennant coll.); Shelford; Torquay (Cudmore and Dennant colls.).

EMARGINULA WANNONENSIS, Harris.

Emarginula wannonensis, Harris, 1897, Cat. Tert. Moll. Brit. Mus., pt. I. Australasian Tertiary Mollusca, p. 288, pl. VIII., figs. 6*a-c* Dennant and Kitson, 1903, Cat. Foss. in Cainozoic of Victoria, S. Austral. and Tasmania, Rec. Geol. Surv. Vict., vol. I., pt. 2, p. 117. Suter, 1915, Alphabetical Hand List of New Zealand Tertiary Mollusca. Wellington, p. 9 (referred to as a living species but without comment).

Observations.—In his original description Harris records this species as doubtfully from the Eocene (regarded by us as Oligocene, Muddy Creek, Vict.) It is interesting to note here the extensive range of this species, which we are enabled to show by the present

7.—Cat. Tert. Moll. Brit. Mus. pt. 1, Austr. Tert., Moll. 1897, p. 288, pl. VIII., figs, 6*a-c*.

series,—from Oligocene to Lower Pliocene. Suter (*op. supra cit.*) has also given it as a living species in New Zealand, but so far we have not met with any occurrence recorded from that or any other area.

The variation in this species is very marked, and speaking generally, the oldest beds (Balcombian) yield the strongest and highest forms; those from the Janjukian are of medium size, whilst the Kalimnan examples, from the Hamilton district, are quite small, being less than a quarter of the size of the older forms. The largest specimen met with (from Clifton Bank, Muddy Creek) has a length of 20 mm., whilst the type described by Harris measures 16 mm.

The smaller and more recent fossil forms of this species resemble *E. transenna*, excepting for the backward position of the apex, which in *E. wannonensis* is vertical with the posterior margin or even overhanging it.

Occurrence.—Balcombian (Oligocene), lower beds, Muddy Creek; Grice's Creek and Balcombe Bay, Port Phillip. Janjukian (Miocene), Gellibrand (Cudmore and Dennant); Murgheboluc (T.S.H. in Cudmore coll.); Shelford (Dennant); Ruttledge's, near Geelong (T.S.H. in Cudmore coll.); Torquay (Dennant); Mitchell River (Dennant); Table Cape Tasmania (Cudmore); Kalimnan (Lower Pliocene). Forsyth's, Grange Burn and MacDonald's, upper Muddy Creek beds (F. Chapman coll.).

Genus MONTFORTULA, Iredale, 1915.

Synopsis of the Genus Montfortula:

Name.	Altitude.	Outline.	Costae.	Base.
M. ponderosa, Chapm. & Gabr.	Very high	Ovate	Numerous; beaded.	Flat.
M, aperturata, Chapm. & Gabr.	Moderately high	Ovate	Numerous; strong; tegulate; interspaces cancellated throughout	Flat.
M. occlusa, Tate, sp.	Medium	Roundly ovate	Few; interspaces cancellated at apex	Flat.
M. gemmata, Chapm. & Gabr.	Medium to low	Roundly ovate	Numerous; finely beaded	Flat.
M. squamoidea, Chapm. & Gabr.	Low	Roundly ovate	Nodulose; feebly cancellated	Flat.
M. cainozoica, Chapm. & Gabr.	Low	Ovate; laterally compressed	Numerous; fine and delicately beaded	Flat.

MONTFORTULA APERTURATA, sp. nov. (Plate II., figs. 18, 19, 20; pl. III.) fig. 34.)

Description.—Shell of medium size, elevated, broadly oval; apex acute, subcentral, slightly reverted. Ornament consisting of about 25 strong rounded ribs with smaller intermediate riblets; these are crossed by a series of undulate and tegulate growth lines with slight

interspaces which give a general cancellate appearance to the shell. Slit shallow, hardly discernible. Slit-fasciole bounded by sharp, laminated borders. The lamellae of the callus becoming nodulous, especially towards the anterior. Sides of shell flattened, anteriorly convex, posteriorly concave under apex and becoming slightly convex towards the margin. Interior of shell polished, marked by faint radial lines; margin of shell flattened, with a fluted and denticulate edge. The slit distinguished by being slightly broader and deeper than the remaining flutings.

Dimensions.—Length, 19 mm. Width, 17 mm. Height, 10 mm.

Observations.—The smaller specimens of this species show a variation towards a more narrowly oval contour which almost amounts to be subspecific difference. A beautiful, ornate species; the generally rounded shape and cancellate ornament separating it from its Victorian fossil congeners. The nearest species with which it might be confused is *M. occlusa*, T. Woods, sp., in which the shell, however, begins with a similar ornament to *M. aperturata*, but rapidly becomes filled in to produce a comparatively smooth shell. Its nearest living Victorian representative appears to be *M. rugosa*, Q. and G., sp.,[8] but in this the shell is stronger and more heavily built, of greater height and with the intermediate riblets more numerous; the slit is also more pronounced than in the fossil species, and in the interior of the shell the slit groove is represented as a distinct furrow almost up to the apex.

Occurrence.—Balcombian (Oligocene), Balcombe Bay (F. A. Cudmore); Muddy Creek, lower beds (F. A. Cudmore and F. Chapman). Janjukian (Miocene), Gellibrand River (J. Dennant); Skinner's, near Bairnsdale (J. Dennant); Murray Cliffs, four miles below Morgan, S.A. (F. A. Cudmore).

MONTFORTULA CAINOZOICA, sp. nov. (Pl. II., fig. 21; pl. III., fig. 36.)

Description.—Shell small, roundly oval, rather tenuous, moderately depressed; apex sharp, sub-central, directed posteriorly. Sculpture, of two systems of riblets, the coarser numbering 48, distinctly granulate; finer riblets filling the interspaces to the number of three or four. Growth lines well marked; and there are three or four resting stages showing concentric sulci on the shell. The characteristic short anterior slit is practically obsolete, but its position is indicated in well-preserved specimens by an ill-defined rib.

Dimensions.—Length, 10·5 mm. Greatest width, 9 mm. Height, 3·25 mm.

Observations.—Nothing comparable is known amongst recent species in the Australian region.

M. cainozoica has a general resemblance to *M. gemmata*, but the ornament of the latter is decidedly stronger and the shell is of much stouter build.

Occurrence.—Balcombian (Oligocene). Muddy Creek, near Hamilton. From the Dennant collection, numerous examples. One speci-

8.—*Emarginula rugosa*, Quoy and Gaimard, Voy. Astrolabe, Zool., 1834, vol. III., p. 331, pl. LXVIII., figs. 17, 18.

ment in F. Chapman's collection from near the top of Clifton Bank, and another from the base of the section, showing that it ranges throughout the Muddy Creek lower beds.

MONTFORTULA GEMMATA, sp. nov. (Plate II., figs. 22, 23, 24.)

Description.—Shell fragile, the type of medium size, moderately high, apex nearly central, anterior notch barely discernible. Surface slightly convex, ornamented by about 24 radial ribs, with smaller interstitial riblets. Growth lines concentric, and at the point where they cross the riblets are developed into gemmules.

Dimensions.—Length, 12·5 mm. Width, 11·5 mm. Height, 6 mm.

Observations.—In general character and ornament this species appears to have no resemblance to any Australian representatives, either Tertiary or Recent. In regard to the variations of the species, we draw special attention to the great modification of forms found under different conditions in our Australian Tertiaries; for example, the type, which came from the deeper water clays of Balcombe Bay, is a moderately small and comparatively high shell, whilst an extreme form is found apparently in the more sandy and littoral deposits of a part of the Muddy Creek, Clifton Bank section, in which the shell is represented as a depressed form, and which has passed on to a gerontic stage attaining the remarkable length of 31 mm. (See Pl. II., fig. 24.) This variation, which is mainly produced by local conditions, can hardly be regarded as constant, or deserving even a varietal name, since we find every gradation between the elevated and depressed forms. The specimens from Gellibrand are relatively small and perhaps intermediate in the elevation of the apex as compared with the above mentioned examples.

Occurrence.—Balcombian (Oligocene), Balcombe Bay, Port Phillip (F. A. Cudmore); Muddy Creek, Clifton Bank (F. A. Cudmore and R. H. Annear). Janjukian (Miocene), Gellibrand River (J. Dennant).

MONTFORTULA OCCLUSA, Tate, sp. (Plate III., fig. 35.)

Subemarginula occlusa, Tate, 1898, Proc. Roy. Soc. N.S. Wales, p. 405, pl. XX., figs 9*a*, *b*. Hall and Pritchard, 1901, Proc. Roy. Soc. Vict., vol. XIV. (N.S.), pt. I., p. 52. Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., vol. I., pt. 2, p. 117.

Observations.—This species is without doubt the commonest and most widely distributed of the Australian Tertiary Montfortulae. The amount of variation seen in a long series of examples is of a surprising extent. In the brephic and neanic stages the shell resembles in some respects those which we have newly described as *M. aperturata;* but whereas the latter retain their character in later stages, in *M. occlusa* the peculiar latticed character of the early stage is speedily lost. Another difference between them and *M. aperturata* is that the apex in the latter is decidedly more acute and salient.

Both in the Balcombian and Janjukian beds of Victoria the variation of this species is normal, but in the Janjukian or Table Cape (Crassatellites Bed) the examples we have seen have fewer and sharper ribs.

Occurrence.—Balcombian (Oligocene), Muddy Creek (Annear coll., a large specimen); Grice's Creek; Balcombe Bay. Janjukian (Miocene), Curlewis (J. H. Young); Fyansford (F. A. Cudmore); Native Hut Creek (T. S. Hall, in Cudmore coll.); Murgheboluc (F. A. Cudmore); Inverleigh (T. S. Hall, in F. A. Cudmore coll.); Shelford, Gellibrand and Table Cape (F. A. Cudmore coll.).

MONTFORTULA PONDEROSA, sp. nov. (Plate II., fig. 25.)

Description.—Shell large, stoutly built, conical and high, with the apex situated posteriorly. Outline of the shell roundly ovate, often irregular in contour, owing to discontinuous stages of growth. Anterior slope of the shell roundly convex; posterior gently concave. Ornament consisting of from 30 to 40 ribs, which are beaded in character, and between which the interspace is generally occupied by a low rounded riblet, also gemmate. In some examples there are two or more intermediate riblets, especially towards the posterior region of the shell. Interior smooth, but with strongly crenulate margin. Notch almost obsolete.

Dimensions.—Holotype (Mitchell River). Length, 22 mm. Width, 19 mm. Height, 14·5 mm. One example from Clifton Bank, Muddy Creek (Dennant coll.) has a length of 22·5 mm. and a height of 17 mm.

Observations.—This species is very distinct. It could not be easily confused with *M. occlusa*, on account of the uniformly beaded ribs and heavy shell; moreover the apex is posteriorly situated in this species, whereas in *M. occlusa* it is central or nearly so.

Occurrence.—Balcombian (Oligocene), Muddy Creek (Dennant coll.). Janjukian (Miocene), Gellibrand River (Dennant coll.); Skinner's and Mitchell River, Bairnsdale (Dennant and Cudmore colls.); also Table Cape, Tasmania (W. L. May coll.).

MONTFORTULA SQUAMOIDEA, sp. nov. (Plate II., fig. 26.)

Description.—Shell large, depressed, roundly oval in outline. Apex not prominent, subcentral. Anterior slope of shell gently convex, posterior, concave. Ornament consisting of about 30 rounded and partially scaly ribs, between which are secondary and sometimes tertiary riblets of the same character. The growth lines crossing the interspaces give rise to a feeble cancellation. Inner surface polished, the margin being relieved with short sulci corresponding with the external ribs.

Dimensions.—Length, 24 mm. Width, 21 mm. Height, 7·25 mm.

Observations.—The only other species of this genus with which the above is likely to be confused is *M. gemmata*. In this, however, the shell is more depressed and the ribs sharper and fewer.

Occurrence.—Balcombian (Oligocene), Muddy Creek, Clifton Bank (Dennant and Annear coll.). Janjukian (Miocene), Western Beach, Corio Bay (Dennant).

Genus Tugalia, Gray.

TUGALIA CRASSIRETICULATA, Pritchard, sp.

Scutus (Tugalia) crassireticulata, Pritchard, 1896, Proc. Roy. Soc. Vict., vol. VIII., p. 125, pl. III., figs 4, 5.

Observations.—This species is apparently confined to the Table Cape beds, and is there very rare. The holotype is in the National Museum Collection, and the only other we have examined is a fragmentary specimen in Mr. Cudmore's collection. The relationships of this species are with the living *Tugalia parmophoidea*[9] and *T. cicatricosa*, A. Adams.[10] From the former it differs in the more oval outline and is altogether a much larger shell, being about two and a half times larger than the recent shell; but the apex in both *T. crassireticulata* and *T. parmophoidea* agrees very closely. On the other hand *T. crassireticulata* is easily separable from *T. cicatricosa* by the character of the apex, which in the fossil does not show a cicatrix. In size the fossil specimen resembles *T. cicatricosa*, but the sides of the shell are much more depressed than in that species.

Occurrence.—Janjukian (Miocene), Table Cape, Tasmania (*Crassatellites* bed); Holotype from Atkinson coll. in the National Museum, also coll. of F. A. Cudmore.

Genus, Megatebennus, Pilsbry.

MEGATEBENNUS CONCATENATUS, Crosse and Fischer, sp.

Fissurella concatenata, Cross and Fischer, 1864, Journ. Conchyl., ser. 3, vol. IV., No. 4, p. 348. Tenison Woods, 1877, Proc. Roy. Soc., Tasmania, for 1876, p. 102.

Fissurellidea malleata, Tate, 1882, Trans. Roy. Soc., S. Australia, vol. V., p. 46. Idem, 1893, ibid., vol. XVII., pt. I, p. 223. Harris, 1897, Cat. Tert. Moll. Australasia, p. 287, pl. VIII., figs 5*a*-*c*.

Megatebennus concatenatus, Crosse and Fischer, sp., Pritchard and Gatliff, 1903, Proc. Roy. Soc., Vict., vol. XV., pt. II., p. 182.

Fissurellidea malleata, Tate, Dennant and Kitson, 1903, Rec. Geol. Surv., Vict., vol. I., pt. 2, pp. 117 and 145.

Original description by Tenison Woods of fossil specimens as "*Fissurella concatenata*" in 1877, op. supra cit., p. 102:—

9.—*Emarginula parmophoidea*, Quoy and Gaimard, 1834, Voy. Astrolabe, Zool. III., p. 325, pl. LXVIII., figs. 15, 16.

10.—*Tugalia-cicatricosa*, A. Adams, Proc. Zool. Soc. Lond., 1852 (1851), p. 89.

"*Fissurella concatenata*, Crosse. Shell thin, oval, laterally and posteriorly depressed, tumid anteriorly, irregularly, concentrically ridged with lines of growth, and covered all over with fine hexagonal depressions which grow broader from apex to margin; foramen oval, with a conspicuous tubercle on each side, and widely margined beneath, interior margin enamelled, and above which the shell is undulately striate or sub-corrugated on the foraminal margin. Long 14, Lat. 10, Alt. 2½ mil. Easily distinguished by its hexagonal markings, in which it differs from any described." Tenison Woods also remarks that "the fossil forms are generally thinner and fragile, and more like the variety found near Sydney."

Observations.—This is an extremely variable species and is one of those Tertiary forms of mollusca which has a great range in time. It is found throughout the Tertiaries, from Balcombian to Werrikooian, and is a living species along the Victorian coast, at Port Phillip and Western Port. It also occurs at Port Lincoln, South Australia, and Lake Macquarie, New South Wales. Our reference of Tate's *M. malleatus* to the living species has been further confirmed by Mr. Chas. Hedley, F.L.S., of the Australian Museum, Sydney.

It is interesting to note the different varietal forms appearing at the various geological stages or horizons. The older forms have the malleate or contused ornament generally of a finer grade than the later, Kalimnan and recent, forms. In outline also, the species is extraordinarily variable; for example, from the same bed, at the Clifton Bank, Muddy Creek, one can select a series of specimens showing modifications between an almost regularly ovate form, to one in which the anterior is almost acuminate. But in all these variations there is no distinct boundary line to separate the forms or definitely group them in any way. The fossil forms from the finer marl beds, especially in the Janjukian, as at Native Hut Creek, and from the Murray Cliffs, South Australia, show generally a much more delicate surface sculpture, whilst the acme of the coarse sculpturing seems to be reached in the Kalimnan of Muddy Creek.

The largest examples are found in the Balcombian of Muddy Creek, one from the Dennant collection having a length of 32·5 mm. and a width of 22·25 mm.

Occurrence.—Balcombian (Oligocene), Grice's Creek (F. A. Cudmore); Balcombe Bay (Cudmore and Dennant); Muddy Creek, lower beds (Dennant coll.). Janjukian (Miocene), Torquay; Skinner's, near Bairnsdale (F. A. Cudmore); Mitchell River, Bairnsdale (F. Chapman coll.); Native Hut Creek (T. S. Hall, in Cudmore coll.); Murgheboluc and Rutledge's (T.S.H. and F.A.C. coll.); Fyansford (Dennant coll.); Shelford (Dennant coll.); Murray River Cliffs, S.A. (F. A. Cudmore coll.); Table Cape, Tas. (F. A. Cudmore coll.). Kalimnan (Lower Pliocene), Muddy Creek, upper beds (Dennant coll.). Werrikooian (Upper Pliocene), Limestone Creek, Glenelg River, Vic. (Dennant coll.).

MEGATEBENNUS LAQUEATUS, Tate sp.

Fissurellidaea laqueata, Tate, 1885, Southern Science Record, vol. I., No. 1, N.S., Jan. 1885, p. 1.

Fissurellidea laqueata, Tate, Dennant and Kitson, 1903, Rec. Geol. Surv. Vic., vol. I., pt. 2, p. 117.

Observations.—The long ovate shape and striate-reticulate ornament of this species renders it easily separable from *M. concatenatus*. Another distinguishing feature is the smooth interior of *M. laqueatus*, whereas that of *M. concatenatus* is radially sulcated.

The largest specimen known to us, from Muddy Creek, has a length of 21·5 mm., a width of 13·5 mm., and a height of 6 mm.

Occurrence.—Balcombian (Oligocene), Balcombe Bay and Muddy Creek (Dennant). Janjukian (Miocene), Torquay (F. A. Cudmore); Gellibrand (Dennant and Cudmore).

MEGATEBENNUS OMICRON, Crosse and Fischer sp.

Fissurella omicron, Crosse and Fischer, 1864, Journ. de Conch., ser. 3, vol. IV., p. 348. Idem, 1865, ibid., p. 41, pl. III. figs. 4-6. Pilsbry, in Tryon, 1890, Man. Conch., vol. XII. p. 174. pl. XXII. figs. 45-47. Pritchard and Gatliff, 1902, Proc. Roy. Soc. Vict., vol. XV. (N.S.) pt. I. p. 182.

Observations.—This species, like *M. concatenatus*, is a living form around the southern coast of Australia. In Victoria it is found in Port Phillip and Western Port. It does not have so extensive a geological range as *M. concatenatus*, its history commencing with the Miocene.

M. omicron is quite distinct from the preceding two species, both in shape and ornament, having a vellicate or pinched-up form of shell, the sides being almost concave and the foraminate apex salient. The ornament consists of fine ridge-like striae, crossed by fine growth-lines, which give it a sub-reticulate appearance.

The Shelford specimen has a length of 15 mm., whilst that of the Kalimnan specimen is 17 mm.

Occurrence.—Janjukian (Miocene), Shelford (Dennant coll.), Murray Cliffs, 4 miles below Morgan, S.A. (F. A. Cudmore coll.), Kalimnan (Lower Pliocene), Muddy Creek, upper beds (Dennant coll.).

Genus Lucapinella, Pilsbry.

LUCAPINELLA NIGRITA, Sowerby sp.

Fissurella nigrita, Sowerby, 1834, Proc. Zool. Soc. Lond., p. 127. Idem, 1841, Conch. Illustr.,, p. 6, No. 51, fig. 47. Reeve., 1849, Conch. Icon., vol. VI., pl. VI., fig. 41.

Megatebennus nigrita, Sow. sp., Pilsbry, in Tryon, 1890, Man. Conch., vol. XII., p. 187, pl. XLIV., figs, 97, 98.

Lucapinella nigrita, Sow. sp., Hedley, 1895, Proc. Roy. Soc. Vict., vol. VII., N.S., pp. 197, 198, pl. XI., figs. 1, 2.

Pritchard and Gatliff, 1903, ibid., vol. XV., pt. II., p. 183. Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., vol. I., pt. 2, p. 138.

Observations.—The fossil examples are indistinguishable from the living ones, though usually rather polished or waterworn. In Victoria the living specimens are found in Western Port, Flinders, Anderson's Inlet and Kilcunda.

Occurrence.—Janjukian (Miocene). Murray Cliffs, 4 miles below Morgan (F. A. Cudmore coll.). Kalimnan (Lower Pliocene). Muddy Creek, upper beds (Dennant coll.).

Summary.

1.—The foregoing revision includes 23 species, belonging to 8 genera, viz., *Cellana, Patelloida, Cocculina, Emarginula, Montfortula, Tugalia, Megatebennus* and *Lucapinella.*

2. Of these, 14 species are new,—

Cellana cudmorei	*E. dennanti*
C. hentyi	*E. maudensis*
Patelloida hamiltonensis	*Montfortula aperturata*
P. multiradialis	*M. cainozoica*
Cocculina praecompressa	*M. gemmata*
C. gunyoungensis	*M. ponderosa*
Emarginula delicatissima	*M. squamoidea*

3.—Those species with the most persistent range in time are—

Patelloida perplexa. Miocene to Recent.

Emarginula wannonensis. Oligocene to Lower Pliocene. Said to be living in New Zealand seas.

Megatebennus concatenatus. Oligocene to Recent

" *omicron.* Miocene to Recent.

4.—The slight variations seen in the above specific forms, continuing throughout an enormous period and dating back in some cases to the older Tertiary, are not striking enough nor of such constant character to justify even varietal names.

5.—This continuity of character in the mollusca over long periods indicates a fairly uniform phase of sedimentation, and where variations have occurred, must have been of a local character, which obviated the rapid evolution of form requiring new adaptations to their surroundings.

6.—From the foregoing work, it is patent to the authors that the description of new forms of fossil mollusca must be studied and compared with the living faunas, especially of the same geographical area. Otherwise unnecessary duplication of nomenclature will ensue.

7.—The complete list of species herein mentioned, with their range in time, is as follows:—

Cellana cudmorei, sp. nov. Miocene.
.. *hentyi*, sp. nov. Lower Pliocene.
Patelloida hamiltonensis, sp. nov. Lower Pliocene.
,, *multiradialis*, sp. nov. Lower Pliocene.
,, *perplexa*, Pilsbry, sp. Miocene and Recent.
Cocculina praecompressa, sp. nov. Oligocene and Miocene.
,, *gunyoungensis*, sp. nev. Oligocene.
Emarginula delicatissima, sp. nov. Oligocene and Miocene.
,, *dennanti*, sp. nov. Oligocene and Miocene.
,, *maudensis*, sp. nov. Miocene.
,, *transenna*, T. Woods. Oligocene and Miocene.
,, *wannonensis*, Harris. Oligocene, Miocene and Lower Plicene (?) Recent in New Zealand.
Montfortula aperturata, sp. nov. Oligocene and Miocene.
,, *cainozoica*, sp. nov. Oligocene.
,, *gemmata*, sp. nov. Oligocene and Miocene.
,, *occlusa*, Tate sp. Oligocene and Miocene.
,, *ponderosa*, sp. nov. Oligocene and Miocene.
,, *squamoidea*, sp. nov. Oligocene and miocene.
Tugalia crassireticulata, Pritchard. Miocene.
***Megatebennus** concatenatus*, Crosse and Fischer sp. Oligocene, Miocene, Pliocene and Recent.
,, *laqueatus*, Tate sp. Oligocene and Miocene.
,, *omicron*, Crosse and Fischer sp. Miocene, Pliocene and Recent.
Lucapinella nigrita, Sowerby sp. Miocene, Lower Pliocene and Recent.

EXPLANATION OF PLATES.

N.B.—All Types are in the National Museum collection.

Fig. 1.—*Cellana cudmorei*, sp. nov. Internal view of shell, in polyzoal limestone. Janjukian. Batesford. Holotype; coll. F. A. Cudmore. $\times \frac{9}{8}$.

,, 2.—*Cellana hentyi*, sp. nov. Apical aspect. Kalimnan. Forsyth's Grange Burn near Hamilton. Nat. Mus. coll. Type; pres., by F. Chapman. $\times \frac{7}{4}$.

,, 3.—*Patelloida hamiltonensis*, sp. nov. Apical aspect. Kalimnan. Muddy Creek, upper beds. Holotype. Dennant coll. $\times \frac{23}{13}$.

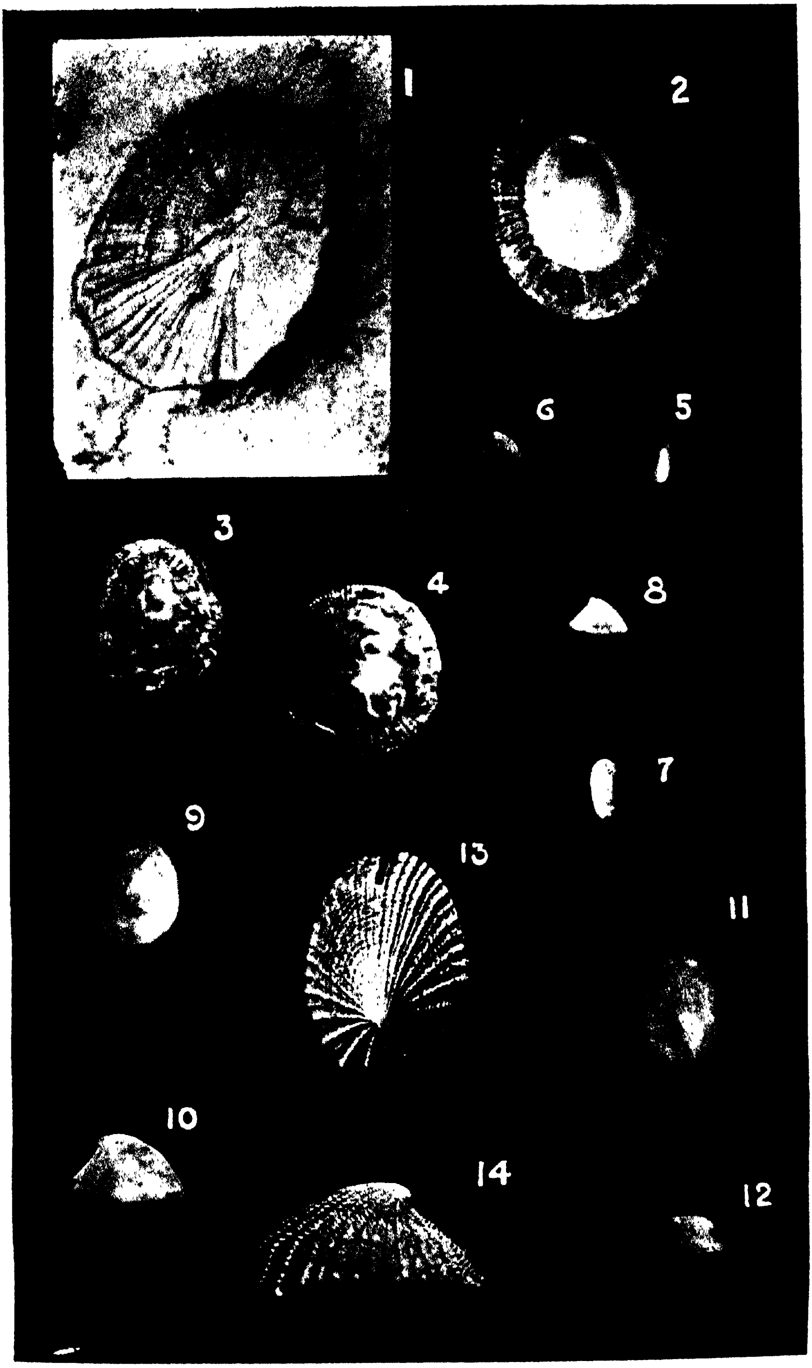
,, 4.—*Patelloida multiradialis*, sp. nov. Apical aspect. Balcombian. Upper part of Clifton Bank, Lower Muddy Creek beds. Holotype, coll. F. Chapman; pres. Nat. Mus. coll. $\times \frac{5}{8}$.

,, 5.—*Cocculina praecompressa*, sp. nov. Apical aspect. Balcombian. Lower beds, Muddy Creek. Holotype; pres. by J. H. Young. $\times$ 2.

,, 6.—Ditto., Lateral aspect. $\times$ circ. 2.

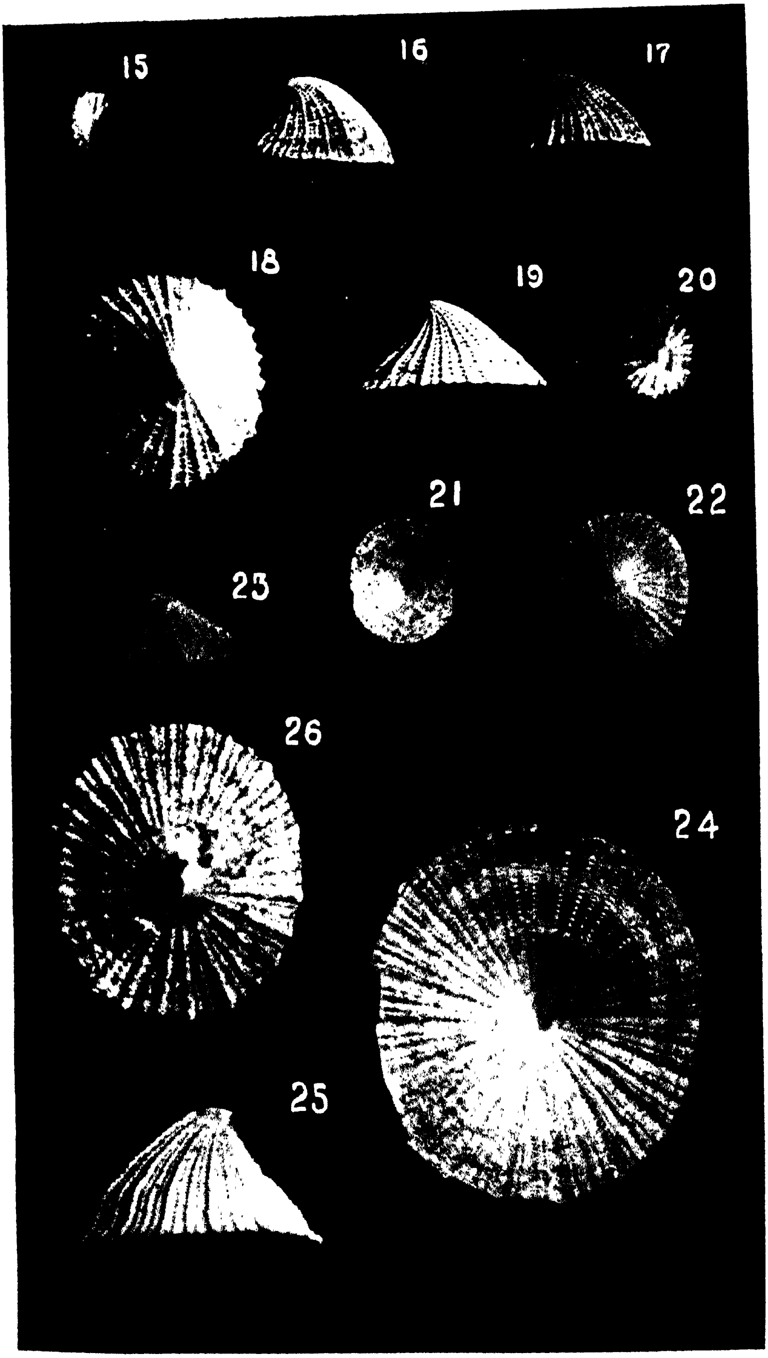
,, 7.—*Cocculina praecompressa*, sp. nov. Apical aspect. Janjukian. Shelford. Paratype. Dennant coll. $\times$ circ. 2.

,, 8.—Ditto., Lateral aspect, $\times$ circ. 2.



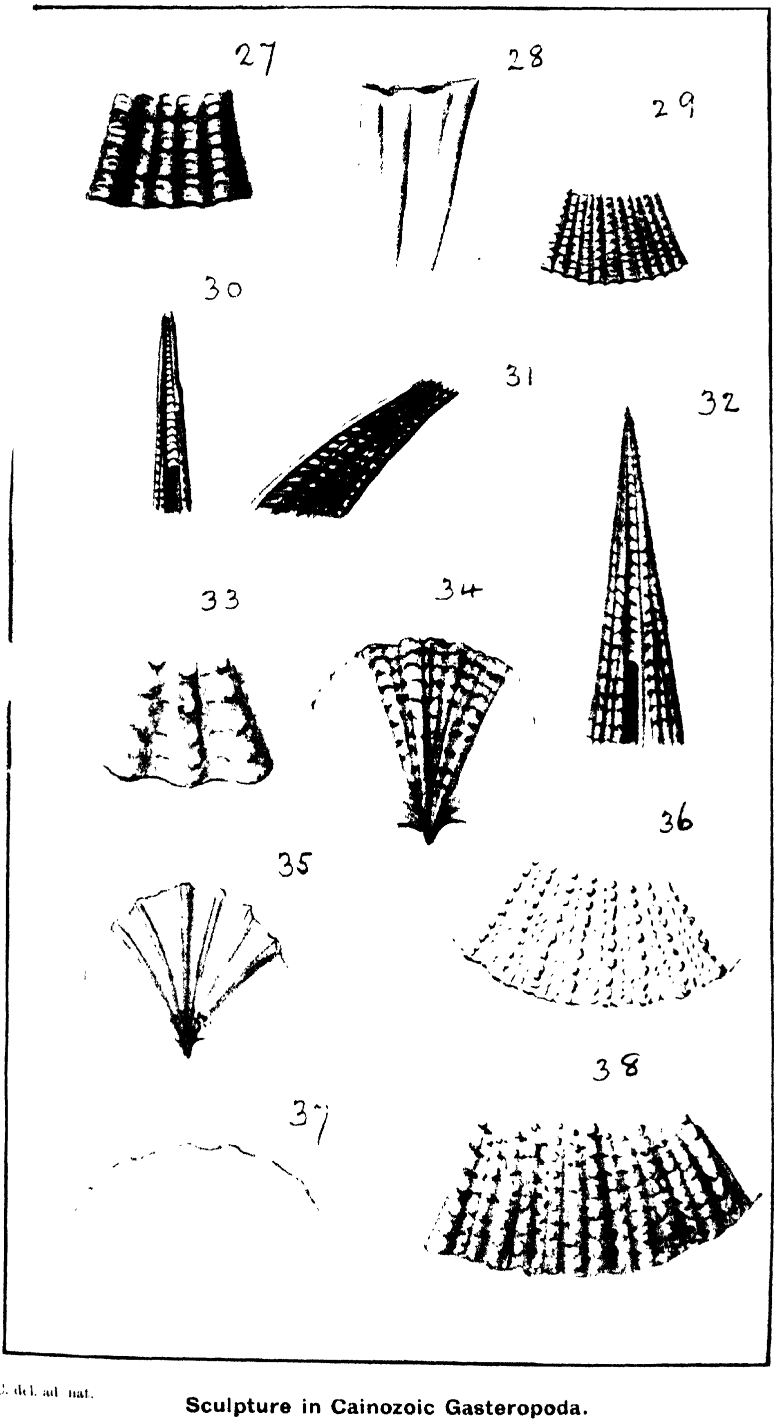
F. C. Photo

Cellana, Patelloida, Cocculina and Emarginula - Cainozoic. Australia.



F. C. Photo

Emarginula and Montfortula -Cainozoic, Australia.



.C. del. ad nat.

Sculpture in Cainozoic Gasteropoda.

„ 9.—*Cocculina gunyoungensis*, sp. nov. Apical aspect. Balcombian. Grice's Creek, Port Phillip. Holotype. Dennant coll. × 5/3.

„ 10.—Ditto. Lateral aspect. × $\frac{5}{3}$.

„ 11.—*Emarginula delicatissima*, sp. nov. Apical aspect. Balcombian. Balcombe Bay. Holotype. Dennant coll. × 5/3.

„ 12.—Ditto. Lateral aspect. × $\frac{5}{3}$.

„ 13.—*Emarginula dennanti*, sp. nov. Apical aspect. Balcombian. Grice's Creek. Holotype. J. F. Bailey coll. × $\frac{7}{4}$.

„ 14.—Ditto. Lateral aspect. × $\frac{7}{4}$.

II.

Fig. 15.—*Emarginula maudensis*, sp. nov. Apical aspect. Janjukian. Maude. Holotype from Dennant coll. × 2.

„ 16.—*Emarginula transenna*, T. Woods. Lateral aspect. Janjukian. Table Cape, Tasmania. Homoeotype from Johnston coll. Tasmanian Museum, Hobart. × circ. 2.

„ 17.—*Emarginula transenna*, T. Woods. Lateral aspect. Balcombian. Grice's Greek. Plesiotype. Pres. F. A. Cudmore. × circ. 2.

„ 18.—*Emarginula aperturata*, sp. nov. Apical aspect. Janjukian. Gillibrand River. Holotype. Dennant coll. × $\frac{5}{3}$.

„ 19.—Ditto. Lateral aspect. × $\frac{5}{3}$

„ 20.—*Montfortula aperturata*, sp. nov. Apical aspect. Janjukian. Skinner s, near Bairnsdale. Paratype. Dennant coll. × circ. 2.

„ 21.—*Montfortula cainozoica*, sp. nov. Apical aspect. Balcombian. Muddy Creek, lower beds. Holotype from Dennant coll. × circ. 2.

„ 22.—*Montfortula gemmata*, sp. nov. Apical aspect. Balcombian. Balcombe Bay. Holotype, pres. by F. A. Cudmore. × circ. $\frac{5}{3}$.

„ 23.—Ditto. Lateral aspect. × circ. $\frac{5}{3}$

„ 24.—*Montfortula gemmata*, sp. nov. Apical aspect of a gerontic form. Balcombian. Muddy Creek. lower beds. Paratype Coll. R. H. Annear. × circ. 2.

„ 25.—*Montfortula ponderosa*. sp. nov. Lateral aspect. Janjukian. Mitchell River. Holotype. Dennant coll. × circ. 2.

„ 26.—*Montfortula squamoidea*, sp. nov. Apical aspect. Balcombian. Muddy Creek, lower beds. Holotype. Dennant coll. × circ. 2.

III.

Fig. 27.—*Cellana cudmorei*, sp. nov. External ornament of peripheral margin. Holotype. Batesford. × 3.

„ 28.—Ditto. Internal surface of shell, posterior margin. × 3.

„ 29.—*Patelloida multiradialis*, sp. nov. External ornament, posterior margin. Holotype. Muddy Creek, lower beds. × 3.

„ 30.—*Emarginula delicatissima*, sp. nov. Slit-fasciole of holotype. Balcombe Bay. × 8.

„ 31.—Ditto. Ornament of side. × 8.

„ 32.—*Emarginula dennanti*, sp. nov. Slit-fasciole of holotype. Grice's Creek. × 3.

„ 33.—*Emarginula maudensis*, sp. nov. Ornament of posterior margin. Holotype. Maude. × 8.

„ 34.—*Montfortula aperturata*, sp. nov. Anterior and apex of holotype, showing continuous cancellation. Gellibrand River. × 2.

„ 35.—*Montfortula occlusa*, Tate sp. Anterior and apex of an example from Gellibrand River, showing apical cancellation and epheb'c laevation of surface. Gellibrand River. Dennant coll. × 2.

„ 36.—*Montfortula cainozoica*, sp. nov. Ornament of posterior margin. Holotype. Muddy Creek, lower beds. × 7.

„ 37.—*Montfortula gemmata*, sp. nov. Interior of holotype, anterior end, showing callused slit and crenate edge. Balcombe Bay. × 4.

„ 38.—*Montfortula ponderosa*, sp. nov. Ornament of lateral surface. Holotype. Mitchell River. × 4.

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. I., 1923.]

ART. IV.—*Studies on the Comparative Anatomy of the Alimentary Canal of Australian Reptiles.*

By WM. COLIN MACKENZIE, M.D., F.R.S.(Edin), F.R.C.S.

AND

W. J. OWEN.

(With Plate IV., and Text. Figs. 1-5.)

[Read 12th July, 1923.]

Introduction.

For a correct understanding of the structure and function of the human body a knowledge of the anatomy and physiology of the reptile is essential, and its importance cannot be too strongly emphasised. Land animals, air breathers, provided in the cases of the monitors and lizards with arms and legs, they enable us to review ourselves from a more primitive standpoint. They represent a living embryology—an embryology in which you can not only study structure, but also function. Here we find respiration carried on without a diaphragm, a heart that has not yet evolved four chambers, undescended testes and a penile grove representing the genesis of a urethra, kidneys placed caudal to the testes and ovaries, a gastro-intestinal arrangement which makes simple the study of the seemingly complex human gastro-intestine, and a miniature spleen, compared with the size of the animal and in contrast to the relatively great spleen found in the lowest mammal—the platypus.

For reptilian study no country offers such a field as Australia; for here we have the large carpet, (non-poisonous) snake, the poisonous varieties such as the black, brown, and tiger, and numerous lizards such as the stump-tailed and blue tongued varieties, as well as the giant lizards or monitors. This work is based on investigations of the following reptiles:—

Carpet snake (non-poisonous) *Python spilotes.*
Brown snake (poisonous) *Diemenia textilis.*
Black snake (poisonous) *Pseudechis porphyriacus.*
Tiger snake (poisonous) *Notechis scutatus.*
Stump-tailed lizard (non-poisonous) *Trachysaurus rugosus.*
Blue-tongued or giant skink (non-poisonous) *Tiliqua scincoides.*
Cunningham's skink (non-poisonous) *Egernia cunninghami.*
Frilled lizard (non-poisonous) *Chlamydosaurus kingii.*
Bearded lizard (non-poisonous) *Amphibolurus barbatus.*
Monitors (non-poisonous) *Varanus varius* and *gouldii.*

Alimentary Canal of Reptiles.

a). Stump-tailed lizard (*Trachysaurus rugosus*)
Frilled lizard (*Chlamydosaurus kingii*)
Bearded lizard (*Amphibolurus barbatus*).
Giant skink (*Tiliqua scincoides*)
Cunningham's skink (*Egernia cunninghami*)

If the ventral wall of one of the above be removed, extending from the mouth in front to the cloacal aperture caudally, we expose a cavity containing not only the stomach liver, intestines, and the genito-urinary system; but the trachea, heart, and lungs as well. We are immediately struck not only by the absence of a diaphragm defining an abdominal from a thoracic cavity, but also by the relatively large liver provided, as in us, with a gall bladder. Beginning from the oral extremity and proceeding caudally we note the following structures:—floor of the mouth and pharynx, trachea crossed by a well defined thyroid gland, heart and great vessels behind which lies the bifurcation of the trachea and commencement of the lungs,

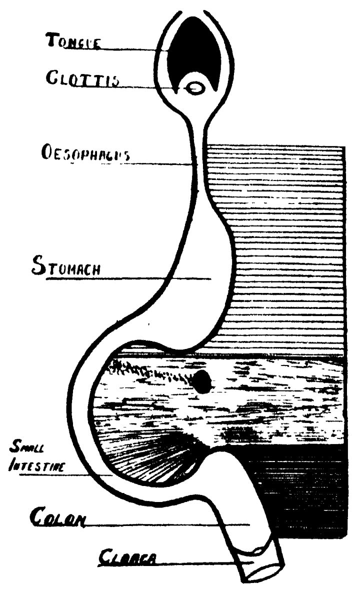


FIG. 1.—Diagram to represent gastro-intestine in skink, stump-tailed lizard, and monitor. The fold connecting the parts to the dorsal wall can be divided into 3 divisions. These from above down are mesogaster, mesentery, and mesocolon. In the mesentery are seen the pancreas and the spleen.

which latter are traced dorsal to the liver and stomach, liver and gall bladder, stomach, small and large intestine or colon, and dorsal to the latter are the ovaries and oviducts in the female, and in the

male the testes and sperm ducts. Most caudal lie the kidneys, one on each side, dorsal to the cloaca.

Mouth and Pharynx.—An examination of the mouth of lizards shows three important differences as compared with mammals.

(1) The laryngeal opening or glottis, lying at the base of the tongue, which is forked for its reception, is not provided with an epiglottis. What may be its precursor is seen in a fold lying in front of the glottis extending from one lingual prong to that of the other. (2) The mouth is not only a conduit for food, but for air as well. At first glance it looks as if the nasal passage were separated from the oral, as the glottis appears to fit into a depression in the palate, but the latter is seen to be incomplete, though this is not so marked e.g. in the stump-tailed lizard as in the giant skink. (3) Though minute mucous-secreting labial and lingual glands are present, we are struck by the absence of defined salivary glands as seen in even such a lowly mammal as the echidna. From this it would appear that true salivary or serous secretion is a characteristic of mammalian life. These factors in connection with the mouth are of first rate importance not only to the physiologist, but to the surgeon also.

The mouth is succeeded by a gradually narrowing pharynx whose length and greatest width is about 3 cm. Its interior is somewhat rugous owing to the presence of fine longtitudinal bands.

Oesophagus.—The gullet is a narrow tube-like structure, measuring about 5 cm. in length with a greatest width of ·5 cm. Its interior, like that of the pharynx, is roughened, owing to the presence of longitudinal folds. There is a well defined sphincter or lock at the junction of the oesophagus and stomach, although we have dissected a stump tailed lizard in which the transition was scarcely evident.

Stomach.—This is a well-defined organ obliquely placed in the general cavity, with its proximal half lying dorsal to the liver, but ventral to the left lung. It gradually narrows towards the pyloric extremity. The pyloric or distal extremity is on a plane ventral to the cardiac or proximal extremity. When moderately distended it is seen to be rugous, which is especially marked towards the pyloric extremity where the longitudinal rugae end abruptly at the pyloric sphincter or lock, which forms a sharp definition between the stomach and the small intestine. The length of the stomach is about 8·5 cm., and the breadth, when moderately distended, is 2·5 to 3 cms. The breadth of the double suspensory fold, or mesogaster, connecting the stomach to the dorsal wall may reach 5 cm.

Small Intestine.—There is no microscopic differentiation of a duodenum, such as we see in mammalia, to be met with in the stump-tailed lizard or skinks. The functional impetus that has necessitated its appearance in the latter has not arisen in these nor in the snakes or monitors. In lizards, such as the bearded and the frilled, that have developed a caecum, a duodenal loop is present, and in these reptiles it is 3 cm. long with greatest width of mesoduodenum

2·75 cm., and of mesentery 6 cm. As in monotremes duodenal glands are not found. The total length of small intestine varies from 12 to 22 cms. It is looped, freely moveable, being swung from the dorsal wall by a suspensory fold or mesentery, whose greatest width may equal 7 cm. In the proximal portion of this fold are seen the diffuse pancreatic organ and the spleen.

Colon or Large Intestine.—The small gut is succeeded abruptly by the colon, from which it is separated, as in man, by a well developed colic sphincter or lock. The colon runs without convolution along the dorsal wall, to which it is related by gradually narrowing suspensory fold or mesocolon, the greatest width at the commencement of which may equal 2 cm. The colon measures 7-9 cm. long and terminates like the bladder, renal, and genital systems, in a terminal compartment or cloaca. Its cloacal opening is extremely minute, easily missed, and is provided with a well defined sphincter.

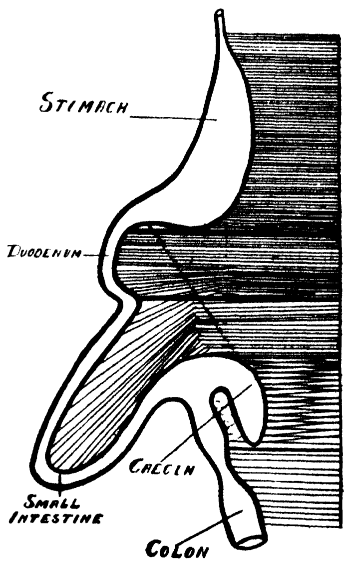
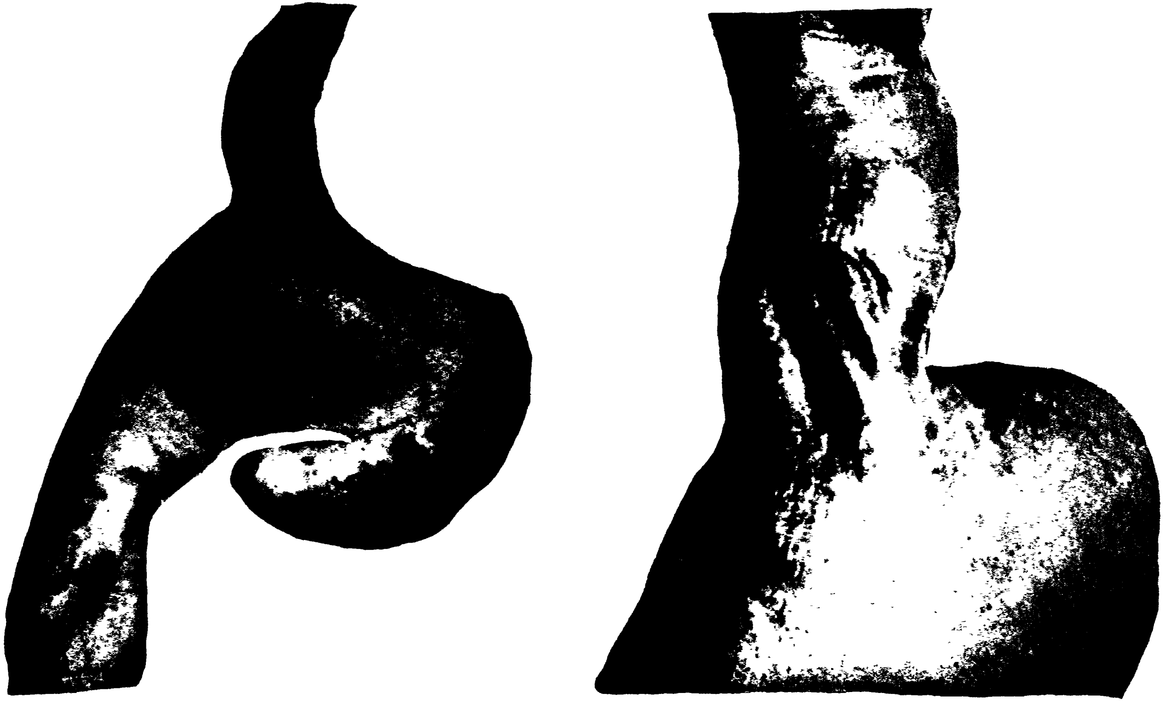


FIG. 2.—Diagram of gastro-intestine in frilled and bearded lizards. The fold connecting the parts to the dorsal wall can be divided into 4 divisions. These beginning from above down are mesogaster, mesoduodenum, mesentery, and mesocolon. The mesoduodenum and mesentery are crossed by the mesial or suspensory fold.

Ventral to the colon lies the bladder, and on either side of the mesocolon lies, in the female, the ovaries and oviducts, and in the male, the testes and sperm ducts. When distended the width of this gut may equal 3 cm. A small unilateral dilatation representing caecal formation is occasionally seen at the commencement of the colon in the giant skink. We have never seen any attempt at caecal formation in the stump-tailed lizard. From the point of view of caecal study,



Junction of small and large intestine in bearded lizard and blue-tongued skink. In the former we see the developement of a well defined curved blind gut or caecum

however, an examination of the frilled and of the bearded, or jew, lizard is of prime importance.

These two reptiles are characterized by the presence of a definite curved blind gut, or caecum, somewhat resembling that seen in Peramelidae. Its length is about 4 cm., and at its commencement the greatest width is 1 cm., but at its termination less than ·5 cm. Its distal, or blind, end is curved towards the colon to which it is connected by a fine mesentery. Serving to connect this portion of the intestine with the pyloric region, is a fold stretching across the mesentery representing the genesis of the mesial or suspensory fold, which is well demonstrated in Koala. It is not present in monitor, giant skink, or stump-tailed lizard—animals not provided with a caecum. The fold is 2·5 cm long, whilst the interval between colon commencement and stomach in the giant skink may equal 6 cm.

When in a bearded lizard, the distance was about 9 cm. from ilio-colic junction to vent, (without including caecal measurement), it was found that the proximal portion of the colon 3 cm. long and width 1·5 cm., was separated from the distal 5 cm. with a width of 1 cm., by a narrow sphincteric portion about ·75 cm. long and width of less than ·5 cm. The sphincteric portion and the distal 5 cm.

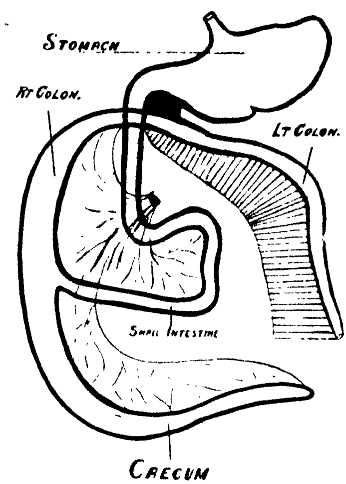


Fig. 3.—Diagram of gastro-intestine in the Australian Koala. The left colon is swung freely on the mesocolon, and the right colon with the small intestine on the mesentery. The colon is suspended at the pyloric region of the stomach by the mesial fold.

were swung on the mesocolon, the proximal portion, with caecum, being swung with small gut on the mesentery, this representing the genesis of the mesenteric colon, which can be best studied in Koala and man. In the frilled lizard it was found that the development

of mesenteric colon and caecum, and their approximation of the pylorus, were even more decided than in the bearded lizard.

Cloaca.—This terminal canal is about 1·5 cm. long, and its transverse outlet, or anus, which has a scaly covering, is guarded by a well defined sphincter. The allantoric bladder lies in front of the termination of the colon, the wall of which is thinner than in the more proximal portion. The bladder opening is ventral to that of the colon. There is a fold separating the colic orifice from the renal and genital openings on each side which lie more dorsally. The penes in the male are connected with the cloaca just within tne sphincter.

We have seen in the stump-tailed lizard the termination of the colon converted into a compartment 1·5 cm. long, each extremity of which was guarded by a sphincter, one colic the other cloacal.

(b) *Monitors.*

Apart from an increased bulk in an animal measuring 50 cm. from snout to vent, the gastro-intestinal tract resembles in its simplicity, that of the stump-tailed lizard and the giant skink. The stomach may reach 20 cm. in length, and is capable of great distention; and even after a moderate feeding, the breadth may equal 8 cm. The small gut reaches 38 cm. long and the colon 17 cm. In one specimen measuring 48 cm. from snout to vent, the length of small gut was 14 cm., and colon 12 cm. The colon, like the stomach, is capable of great distension, and, when moderately enlarged, its

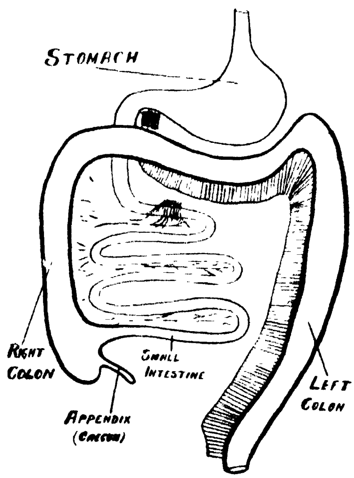


Fig. 4.—Diagram to illustrate the human gastro-intestinal tract. Owing to dorsal fixation in response to the erect posture, only the small intestine and lower portion of the right colon are swung on the mesentery. The mesentery of the greater portion of the right colon, and the mesocolon of the left colon are not now demonstratable as in Koala, although shown in the diagram.

breadth may equal 3 cm. There is no caecum, and no mesial suspensory fold, such as we find in the bearded lizard. The cloacal arrangement is similar to that above described.

(c) *Snakes. (Ophidia).*

In the Australian snakes, both poisonous and non-poisonous, from the point of view of peritoneal relationship and functional differentiation, we are dealing, as in the case of lizards, with a simple condition of gastro-intestine. There is no development of great omentum, caecum, or mesenteric colon, neither is there differentiation of a duodenum, although, in the carpet snake, a diverticu-

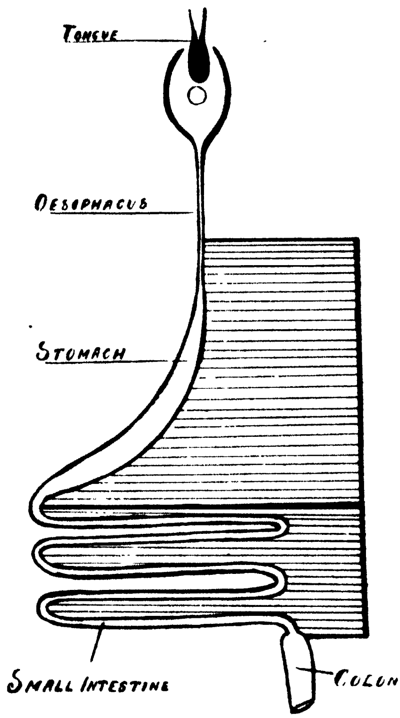


Fig. 5.—Diagram to illustrate the gastro-intestine of Australian snakes.

lum resembling, as regards size and shape the appendix of the echidna, is met with. Compared with that of the lizard, the gastro-intestine gives the idea of elongation, of having been drawn out to accommodate itself to body contour. The tongue is narrow, forked at the extremity, and obtrudes from, or retracts within, a sac on the floor of the mouth, the opening of which is immediately in front of the glottis. The tongue is often confused in the lay mind with the fangs. The pharynx measures 2-3 cm. with a greatest width of 2 cm. The oesophagus is long measuring on an average 36 cm. with a width of 5 cm. The stomach is a curved rounded elongate body

the interior of which is rugous owing to the presence of well defined longitudinal folds which end abruptly at the pyloric sphincter, and are especially well marked in the carpet snake. In the collapsed state the stomach measures about 9 cm. long, with a greatest width of 1 cm. In the carpet snake, the width of collapsed stomach may equal 5 cm. Compared with the lizard the snake is characterized by the presence of an elongated small intestine, swung on the mesentery, and bunched, for purposes of space economy, into a number of convolutions or loops. It measures about 80 cm. in length and joins the colon abruptly, there being no caecal formation at the junction. The colon measures about 6 cm. in length with a width of 1-1·5 cm., and is swung on a gradually narrowing peritoneal fold or mesocolon. It terminates at the proximal part of the cloaca on its ventral aspect by a small sphincteric opening.

Remarks by Dr. MacKenzie on the Clinical Significance of the foregoing.

The above investigations were made with a view of throwing light on the seemingly complex human intestine, the dorsal fixation of which is correlated to the assumption of the erect posture. The basis of the investigations was the principle that the great advance from the reptiles along the mammals up to man is one of muscular action.

If we compare the "lowest" with the "highest" mammal we find that the general structural scheme is the same in both. We have e.g., a four chambered heart, diaphragm, large spleen, lungs similar and localized to the chest. Furthermore, the brain in the monotreme, unlike that in the reptile, has assumed the human type in which the grey matter is external to the white. The overflow of grey matter has already occurred, and the architecture of the monotreme's brain is decidedly human. The functional impetus that has made necessary in the mammal the four chambered heart, lungs confined to the thorax with increased air space, a respiratory piston or diaphragm, and the overflow of grey matter in the brain is correlated to the use of limbs not only for progression but for support. The great impetus has been the necessity, owing to its numerous advantages—advantages which have shown their response in brain structure—for the body to be erect on two limbs. In the monitor or lizard we see progression on the belly wall; in the platypus on belly wall and limbs; in the echidna on fore and hind limbs; in the kangaroo two hind limbs and tail; and in the orang two hind limbs with the slight use of the fore limb. Finally we have two legs only as in man with the front limbs not merely hanging appendages, but structures capable of themselves being raised against gravity when the body is in the erect position.

To this everything in so called "higher" mammalian development would appear to be subservient. The great difference between the echidna with its richly convoluted brain, and us, is that we have erect posture, and it has not. The reason for the marked

difference between the brain of the platypus and echidna is explained by the fact that in movement the former still shows its reptilian affinity, whilst the echidna is definitely off the ground well balanced on its four limbs. The " erect " position in man at the present stage is unstable, and a period of three years is spent by the infant in acquiring balance. The medical practitioner dealing with nervous or muscular disease, recognizes its experimental nature, and hence vulnerability to attack. One might assume, also, that nervous and muscular diseases flourished during that transition when limbs were asked not only to propel, but to support. A commencement of study of the erect posture, not only as affecting the muscular and nervous system, but every other system of the body whether intestinal, genital, or cardiac, must be made in the reptile; and if one could generalize about human disease it would be along the lines of failure to accommodate to it. Thus we see the importance of a study of the reptilian intestine in explaining the human. The colon, or large intestine in man, though divided up by human anatomists into no less than nine portions, really consists of two parts, viz.: a right, new, experimental, or mesenteric colon and an old, left, or mesocolic, as is well shown in Koala and Trichosurus. The colic arch is related to the pyloric region of the stomach by a suspensory band—the mesial fold—and from this the dorsal fixation of the intestine correlated to the erect posture really begins. With two exceptions, the gastro-intestine of Australian snakes, lizards, skinks, and monitors shows a primitive arrangement of stomach, small intestine, and colon with the peritoneal divisions of mesogaster, mesentery, and mesocolon. There is no development of caecum, duodenum, or mesocolic colon. In the bearded and frilled lizard, however, in which there is a decided upward trend from belly wall to limbs, a definite caecum and new, or mesenteric, colon have developed, and correlated to this we see the genesis of the mesial fold connecting this region to the pyloric one of the stomach, and also the differentiation of a duodenal loop. A comparison of the brain of the bearded lizard with that of the giant skink, stump-tailed lizard or monitors shows a marked atrophy of the olfactory nerve in the former, compared with the latter, and also development of the pyriform lobe on the under surface. It forms an important link in the development of the brain of the platypus, regarded as the " lowest " mammal. In the platypus we have, compared with the reptile, great splenic development. In the reptile there is no lesser sac—the great omentum not having made its appearance. In the platypus there is a well defined great omentum (lesser sac), which is correlated to the relatively great splenic enlargement. The " great omentum " would be better termed " splenic omentum." Originally the splenic omentum has no connection either with the left colon or its mesocolon. They are not, as is taught in human anatomy books, boundaries of the lesser sac. As we approach the erect posture of man, peritoneal adhesions, or stays, are sent out from the omentum to the left colon and mesocolon, as can be seen in the monkey, ape, and man, the genesis of which can be studied in Macropus.

[Proc. Roy. Soc. Victoria, 36 (N.S.). Pt. I., 1923.]

Art. V.—*The Evidence of Post-Lower Carboniferous Plutonic and Hypabyssal Intrusions into the Grampian Sandstones of Western Victoria.*

By ERNEST W. SKEATS, D.Sc., A.R.C.S., F.G.S.
University of Melbourne.

(Plates V. and VI.)

[Read 12th July, 1923.]

Introduction.

The interest of the present communication lies in the definite establishment in Victoria of plutonic intrusions younger than the Lower Carboniferous period.

Apart from this area no plutonic rocks younger than Lower Devonian in age have hitherto been proved or suggested to exist in Victoria. In 1913 I spent a fortnight in geological examination of the Grampians region with Mr. Ferguson, of the Geological Survey of Victoria, and the present paper is based on field evidence obtained during that visit, supplemented by later petrological examination of the specimens then collected.

Previous Literature.

The literature dealing with the relations of the igneous rocks to the Grampian sandstone is included in the following papers:—

1. F. M. Krause, Progress Report of Geol. Survey of Victoria, No. 1, 1874, pp. 125-126 (with geological map and sections).
2. H. Herman, Special Reports Mines Dept. of Victoria, 1900, pp. 1-7 (with geological map and section.)
3. T. S. Hart. Proc. Roy. Soc. Vict., Vol. XX. (N.S.), Pt. 2, 1907 (issued 1908), p. 269.
4. E. J. Dunn. Records Geol. Surv. Vict., Vol. III., Pt. 2, 1912, p. 116 and p. 118.
5. W. H. Ferguson, Records Geol. Surv. Vict., Vol. IV., Pt. 1, 1917, pp. 5-9.

The evidence, as to the relations of the igneous rocks of the area to the Grampian sandstone, included in the above papers may be summarised as follows:—Krause expressed himself as doubtful of the relations, but published a geological section showing the granite as intrusive into the sandstone. H. Herman could find no evidence of intrusion, and quoted A. W. Howitt as identifying the plutonic igneous rock as "quartz-mica-diorite (L. Devonian?)." T. S. Hart evidently believed the plutonic rock to be older than the sandstone

and thought the dykes in the sandstone were more probably allied to the Coleraine trachytes than to the granitic rocks.

E. J. Dunn stated that where the granite is first seen on the road from Hall's gap the beds of sandstone are altered to quartzite by contact metamorphism, showing the granite to be more recent than the Grampian sandstone. W. H. Ferguson stated that from general field evidence it appears that the granodiorite and porphyries are intrusive into the sandstone. This conclusion is based on the following evidence: —1. Near the granite rocks the sandstones are in many places altered into quartzites. 2. In some places small dykes appear to extend from the granodiorite into the sandstones. 3. True quartz veins in the sandstones have been noted only close to the contact of granodiorite or porphyry. 4. No conglomerate containing granite boulders or quartz derived from granite rocks was found at the base of the sandstones where they rest directly on the granodiorite.

Discussion of Previous Literature.

With reference to Mr. Hart's statement that the dykes in the sandstone are more closely related to the Coleraine trachytes than to the granitic rocks evidence will be quoted below showing that this view is incorrect and that the dykes are mineralogically and genetically related to the plutonic intrusions.

Mr. Dunn's communication gives the first positive statement of the intrusion of the granite into the sandstones, but the evidence cited viz., the presenc of quartzite along the contact, is, by itself, not convincing proof. The quartzites might be metasomatic in origin and due to deposition of silica from downward migrating solutions arrested in their movement through the sandstones by contact with the plutonic rock.

Mr. Ferguson's evidence is cumulative and fuller, and adds to the evidence of the quartzite the recognition of the limitation of the quartz veins to the contact zone, and the statement that small dykes "appear" to extend from the granodiorite into the sandstone. In addition he quotes the negative evidence of the absence of granitic conglomerates at the contact.

In view of the interest of the occurrence I wish to supplement the evidence published by Messrs. Dunn and Ferguson by my own observations in the field and by evidence based on microscopic examination of the rocks collected.

Field Evidence.

Evidence was obtained from the Mt. William goldfield in the south, from near the Wartook Reservoir in the north, and from near Hall's Gap in the central part of the area. Interest centres in two questions—(1) The nature of the contact of the sandstones with the plutonic rock and (2) the relations of the hypabyssal igneous rocks to the sandstones.

1. The contact of the sandstones with the plutonic rock.

(a) Mt. William goldfield. In the upper tunnel of the Coronation mine the plutonic rock occurs on the floor of the tunnel while sandstone or quartzite forms the roof for a considerable distance. The plutonic rock is decomposed but sends small igneous veins into the sandstone. (Sketch section a).

(b) Three miles from Wartook Reservoir towards Rosebrook. Here the contact of quartzite and plutonic rock runs along the road on a ridge. As Mr. Ferguson has stated, at this place a dyke occurs in the plutonic rock near the junction and another within the quartzite, which can be traced to within a few feet of the junction. The two dykes both in hand specimens and in section are petrologically identical. The sandstones near the junction are converted into quartzites, and an important additional piece of evidence of the intrusive character of the plutonic rock is yielded by the observation that the quartzites along the contact and for a few feet away from it are completely primsmatized and readily break up or weather into somewhat irregular but definite polygonal prisms. (Sketch plan and section b.)

2. The relations of the hypabyssal igneous rocks to the Grampian sandstones.

Mr. Ferguson has referred to the fact that many dykes cutting across the bedding of the sandstone are to be seen in various parts of the area while in other cases they appear to have been thrust into the sandstones along the bedding planes. It follows from this that both dykes and sills are present. This evidence is supported by my own observations, and it becomes of importance if it can be shown that these hypabyssal rocks are genetically related to the plutonic rocks. In the field going southwards along the mining tract, after crossing Stony Creek and just above Venus' Bath, the sandstones strike N.20°E. and dip W.20°N. at 27°. At this point there is a junction with a porphyrite which is here about 28′ thick. The igneous rock at first lies evenly between the bedding planes but further on it cuts across the beds of sandstone making an irregular junction. The rock is therefore not an interbedded flow but an intrusive rock, partly sill, partly dyke. (Sketch section c.) The sedimentary rocks immediately below the intrusion, however, are sandstones, while five chains along the road and above the intrusion the rocks are quartzites. This indicates the necessity of caution in using the presence or absence of quartzite near the igneous contact as evidence of intrusion or otherwise. Several porphyrite dykes occur further south on this road towards the Stony Creek dredge and gold workings. On the stairway to Mt. Rosea, as Mr. Ferguson has stated, a decomposed porphyrite dyke 5—10′ thick, occupies a fault plane cutting across the quartzite. (Sketch section d.) At the McKenzie Falls, three miles S.S.W. from Wartook Reservoir, the falls, which have a throw of about 100 feet, are caused by differential erosion between the sandstones which here dip N. 20° E. at 10° and a big vertical porphyrite dyke striking E. and W. and cutting across the sandstone. (Sketch section e.)

Microscopic Examination of Igneous and Sedimentary Rocks.[1]

PLUTONIC TYPES.

One analysis described as granite from Mt. William, near Stawell, from Ann. Rep. Mines Dept., Vic., 1900, p. 37, by H. C. Jenkins, is available. It is as follows:—SiO_2 = 66·86; Ae_2O_3 = 14:91; Fe_2O_3 = 4·06; FeO = 3·65; MnO = tr; CaO = 3·25 MgO = 1·28; Na_2O = 4·22; K_2O = 1·49; H_2O + = 0·9; H_2O — = 0·58. Total = 100·39.

This analysis, together with the great abundance of plagioclase in the rocks, indicates that they can be appropriately described as granodiorites.

No. 1254. Fresh porphyritic hornblende grano-diorite. Coronation tunnel, Mt. William. (Plate I. Fig. 1.)

Green hornblende is abundant, a little brown biotite occurs, abundant zoned plagioclase, probably andesine and large quartz crystals. A later crop of small quartz crystals included in and intergrown with smaller felspar crystals gives the appearance of a coarse ground mass. Accessory minerals include ilmenite, sphene, zircon, and calcite.

No. 1255. Porphyritic hornblende grano-diorite, 300 yards N.W. of dredge, Stony Creek.

The minerals present are similar to those in No. 1254, but chlorite and epidote occur and the plagioclase is in part cloudy. The rock is rather finer in grain and the holocrystalline ground mass of smaller quartz and felspars rather more prominent.

No. 1266. Porphyritic hornblende biotite grano-diorite, Wannon Valley, three miles below Mafeking.

The mineral content is similar to the previously described rocks, much of the plagioclase is cloudy and biotite is more abundant than in Nos. 1254 and 1255.

HYPABYSSAL TYPES.

No. 1253. Microspherulitic quartz porphyrite dyke, Wartook dam.

Phenocrysts of zoned and partially corroded andesine and corroded quartz are set in a ground mass in part microspherulitic in texture, consisting of laths of plagioclase, sometimes radially arranged, of which some are clear and others cloudy, interstitial quartz, ragged, minute crystals of biotite more or less altered to green chlorite, opaque crystals of ilmenite altering to leucoxene, and a little epidote and zircon.

No. 1262. Quartz felspar porphyrite, Broken Falls, McKenzie's Creek.

Large porphyritic cloudy crystals of plagioclase and corroded and embayed crystals of quartz with large green chlorite, after biotite are set in a microcrystalline matrix of cloudy felspar and of quartz with

1 The numbers of the specimens are those of rock sections in the collection of the University of Melbourne.

fairly abundant ilmenite. Small irregular areas of purple and of colourless fluorspar are also present.

No. 1256. Hornblende porphyrite, road above Venus' Bath, Hall's Gap.

Hornblende, altered to chlorite and a carbonate, and plagioclase, cloudy through alteration, occur as phenocrysts. The microcrystalline ground mass consists mainly of quartz and cloudy felspar. In addition there are present ilmenite, a carbonate and epidote.

No. 1264. Microspherulitic quartz felspar porphyrite dyke in sandstone near granodiorite, three miles from Wartook.

Phenocrysts of clear and partially cloudy plagioclase and of corroded quartz in a matrix, partly microcrystalline to micrographic and partly microspherulitic, of quartz and felspar with subordinate biotite sphene and needle-shaped apatite.

No. 1265. Microspherulitic quartz felspar porphyrite vertical dyke at big falls near Wartook. (Plate V Fig. 2.)

Phenocrysts of plagioclase, corroded quartz and biotite and hornblende, the two latter altered to chlorite and epidote set in a micrographic to microspherulitic matrix of quartz and felspar with some ilmenite, zircon and epidote.

Dyke and Sandstone Content

No. 1263. Quartz felspar porphyrite in contact with quartzite, at McKenzie Falls.

The dyke consists of phenocrysts of plagioclase and quartz in a silicified ground mass consisting mainly of microscopic microspherulitic aggregates of chalcedony with negative elongation of fibres. The quartzite consists mainly of quartz grains with few felspar grains, which are partly interlocking but which are mainly set in a ground mass of secondary quartz aggregates indicating the conversion of a sandstone into a quartzite.

Sandstones.

Sandstones from building stone quarry, North of Hall's Gap.

The principal constituent consists of rounded and subangular clastic quartz fragments, a few rounded, clastic grains of tourmaline and a few felspar fragments with a small amount of definite matrix, probably partly felspathic, partly siliceous. The rock is a typical unaltered sandstone.

This rock is to be contrasted with sandstones altered to quartzites at or near the contact with porphyritic granodiorite at Coronation Tunnel, near the dredge in Stony Creek, and from a locality about three miles S.W. of Wartook Reservoir.

Quartzites.

No. 1258. Prismatized quartzite at contact with plutonic rock about three miles from Wartook Reservoir.

The rock is a quartzite consisting of relatively large and closely interlocking crystals of quartz with a subordinate amount of iron-

stained felspathic (?) interstitial matter. No rounded, clastic boundaries remain and abundant microscopic inclusions or bubbles pass across the boundaries of the interlocking quartz crystals.

No. 1260. Quartzite at contact with plutonic rock, 250 yards N.N.E. of dredge in Stony Creek.

A quartzite with large interlocking quartz crystals and abundant strings of linear inclusions passing across the boundaries of the crystals. Very minute rounded prismatic secondary brown and blue tourmalines are included in the quartz crystals. A little secondary white mica is also present.

No. 1259. Felspathic quartzite from Pincombe's shaft, Coronation tunnel, Mt. William.

A quartzite with coarse-grained interlocking quartz crystals and fairly abundant kaolinized felspar and secondary white mica. Minute rounded bulbs of felspar or glass are included in the larger crystals.

Summary of Field and Microscopic Evidence.

The field evidence quoted above shows that the granodiorite in places sends veins into the sandstones, that the sandstones in contact with the granodiorite are not only converted into quartzite but that in some cases the latter are definitely prismatized. Further, dykes of similar character occur both in the plutonic rock and also cutting the sandstones a few feet away from the contact. Among the hypabyssal rocks both dykes and sills are represented, but the alteration effected by these on the sandstone is capricious, being in places notable and in others negligible.

The microscopic evidence shows that a very close resemblance in mineral composition can be traced between the plutonic and the hypabyssal types since hornblende, andesine, biotite and quartz occur in nearly all the types examined. There can be no doubt, therefore, that both the plutonic and bypabyssal rocks were derived from a common magma and belong to the same geological period of igneous activity. Further proof of the intrusive character of the plutonic rock is yielded by the evidence that the alteration of the sandstones to quartzite at the contact is of the contact metamorphic and not of the metasomatic type. This is established by the almost complete interlocking of the crystals, the general absence of a secondary quartz matrix, by the presence of secondary non-clastic tourmaline, of secondary white mica, by the occurence of blebs of glass or felspar in the quartz crystals and by the linear arrangement of inclusions or of bubbles passing through the interlocking quartz crystals. The field and microscopic evidence, therefore, conclusively demonstrates the intrusive character of the plutonic rocks as well as of the hypabyssal sills and dykes of the Grampians region. The age of the Grampian sandstone on the available fossil evidence is stated to be Lower Carboniferous. The plutonic rock, with its associated dykes and sills is, therefore, clearly of post-Lower Carboniferous age.

The Relation of the Granodiorite and of the Hypabyssal Rocks to Earth Movements in Victoria.

It has hitherto been accepted that no marked fold movements have occurred in Victoria later than the Lower Devonian period since in general the Silurian sediments are the youngest to show widespread, and sometimes acute, folding, while the Middle and Upper Devonian sediments, often tilted to a high angle by faulting, are not known to be closely folded. At Buchan, in Eastern Victoria, however, the Middle Devonian limestones locally show well-defined and fairly acute anticlines while normally the dips are fairly low. The general association of plutonic intrusions with mountain making movements and with folding by compression raises the question, now that the granitic rocks of the Grampians are shown to be younger than the Lower Carboniferous, as to whether later fold movements, of a less severe character perhaps, may not have occurred in Victoria. Such later movements are well known in Northern New South Wales and in Queensland, but have not hitherto been recognised in Victoria. The available evidence is as yet too scanty for any but tentative suggestions. It may be, however, that the preservation of the Lower Carboniferous sandstones in Western Victoria is to be associated with broad geosynclinal down-warping with accompanying faulting in that region closely following the period of their deposition. In this connection it is to be noted that Krause[1] refers to the general synclinal structure of the Grampian sandstones about a meridional axis situated just at the western foot of the Victoria Range, while the older Palaeozoic rocks exposed in the area have also a suggestion of synclinal structure complicated by faulting, for high easterly dips occur in the western part of the area and high westerly dips in the eastern part of the area. The broad geosyncline of the Grampians sandstone is also affected by strike faulting[2]. Although the present physiographic features of the area are geologically more recent and probably in great measure controlled by the late Kainozoic movements of differential uplift, these are superimposed upon earlier structures. It may well be that the formation of the main geosyncline occurred during the Middle to Upper Carboniferous periods since rocks older than this period shared in the movements while younger rocks, such as the Permo-Carboniferous or late Carboniferous glacials, appear to occur in Victoria as unconformable plasters with very low dips, except where, as in part of the Bacchus Marsh district, they have been tilted in the neighbourhood of late Kainozoic faults.

We may tentatively conclude that, closely following on the probably Middle or Upper Carboniferous period of geosynclinal downwarping in Western Victoria, there was an uprising of magma from beneath the geosyncline which, penetrating through tension cracks in the sandstones, consolidated as porphyrite dykes and sills in the sandstones, while the bulk of the rising magma consolidated slowly

1. Op cit. supra., p.p. 125-126.
2. T. S. Hart, op. cit. supra.

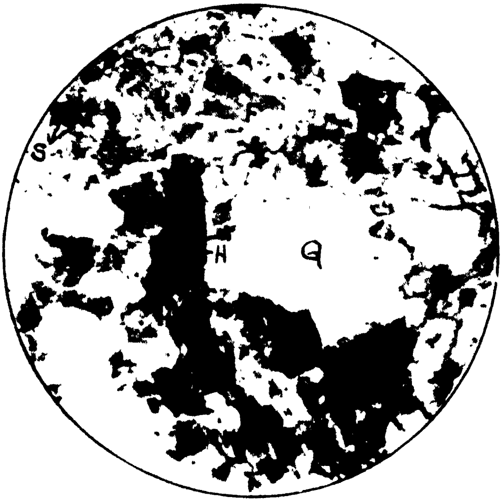


Fig. 1. × 23 diams.

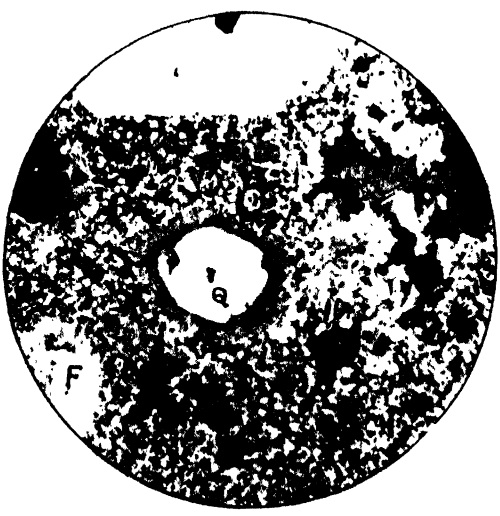


Fig. 2. × 23 diams.

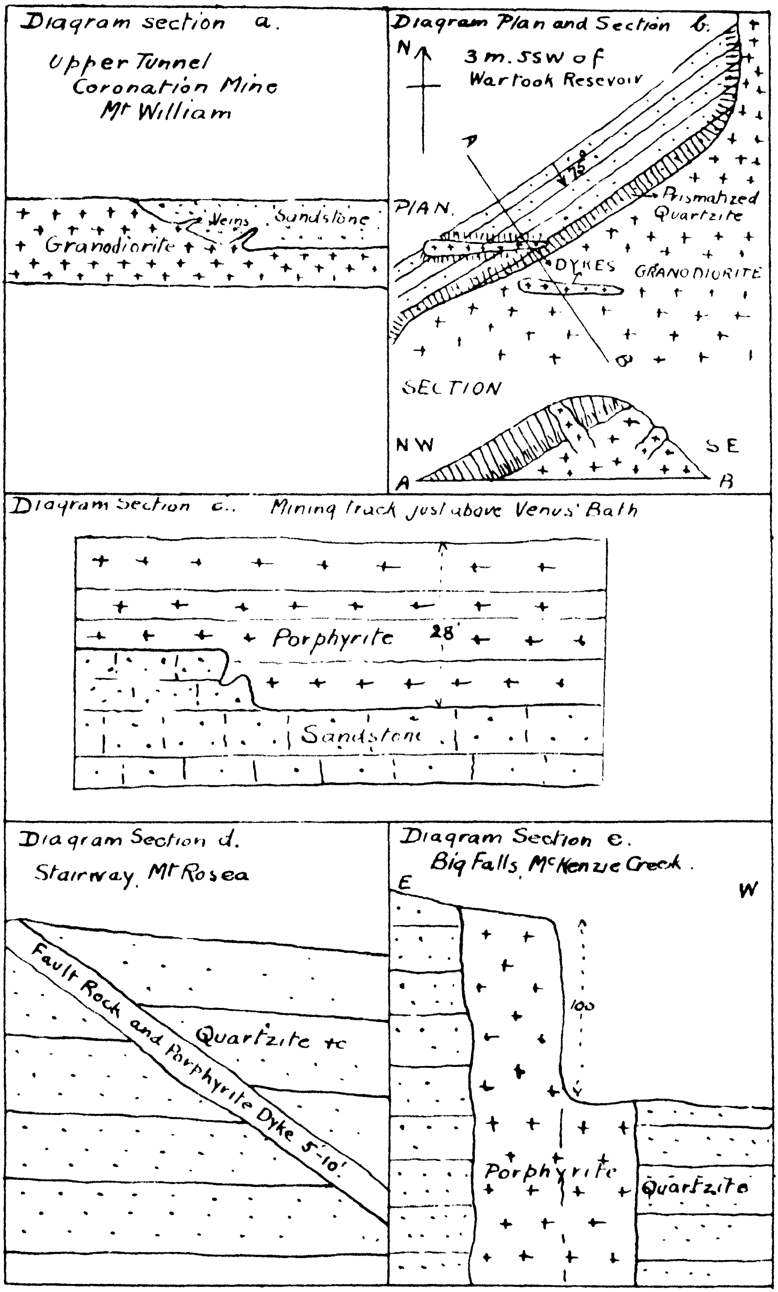


Diagram section a.
Upper Tunnel
Coronation Mine
Mt William
Veins
Sandstone
Granodiorite
Diagram Plan and Section b.
N
3 m. SSW of
Wartook Resevoir
75
Prismatized
Quartzite
PLAN.
DYKES
GRANODIORITE
SECTION
NW
SE
A
B
Diagram Section c. Mining track just above Venus' Bath
Porphyrite
28'
Sandstone
Diagram Section d.
Stairway, Mt Rosea
Fault Rock and Porphyrite Dyke 5'-10'
Quartzite &c
Diagram Section e.
Big Falls, McKenzie Creek.
E
W
100
Porphyrite
Quartzite

under conditions of moderate pressure to form the relatively fine-grained porphyritic granodiorite of the Grampians region.

PLATE V.

Description of Microphotographs.

Fig. 1 (No. 1254). Porphyritic hornblende granodiorite, Coronation tunnel, Mt. William. Ord. light × 23 diams.

H = Hornblende, Q = Quartz, F = Felspar, S = Sphene.

Fig. 2 (No. 1265). Microspherulitic quartz-felspar porphyrite. Vertical dyke at big falls near Wartook. Ord. light × 23 diams.

Q = Quartz, F = Felspar, Il = Ilmenite.

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. I., 1923.]

ART. VI.—*New Australian Micro-Lepidoptera.*

BY A. JEFFERIS TURNER, M.D., F.E.S.

(Read 12th July, 1923.)

Fam. ORNEODIDAE.

ORNEODES XANTHOSTICTA, n.sp.

♂ 13 mm. Head yellow; face white. Palpi whitish; a slight fuscous suffusion on outer surface of second joint. Antennae white. Thorax and abdomen yellow. Legs whitish; anterior tibiae suffused with fuscous. Forewings and hindwings yellow; wing segments very obscurely barred with whitish; a series of fuscous dots on segments at $\frac{1}{3}$, and another double series at $\frac{2}{3}$; a series of subapical fuscous dots.

Very similar to *O. xanthodes*, Meyr., but much smaller, with white face and antennae, no fuscous costal spots, but with subapical dots; *xanthodes* expands 20 mm.

Queensland: Rosewood in April; one specimen taken at light.

Fam. ELACHISTIDAE.

BATRACHEDRA SILIGINEA, n.sp.

♂ ♀ 10-18 m.m Head and thorax whitish-grey; face whitish. Palpi whitish; second joint with three blackish rings, basal, median and subapical, the last two sometimes confluent, without any apical tuft; terminal joint $\frac{1}{2}$, with a median blackish ring. Antennae whitish, annulated with blackish. Abdomen grey; base of dorsum ochreous-tinged. Legs whitish irrorated, and tarsi annulated, with grey. Forewings narrow, apex round-pointed; whitish irrorated throughout with grey, but less so towards dorsum; a small longitudinal blackish mark on fold at $\frac{1}{3}$, a second in middle of disc, and a third in disc at $\frac{3}{4}$; cilia grey-whitish with a few fuscous points around apex. Hindwings linear-lanceolate; pale-grey; cilia 8, grey-whitish.

Very like *B. mylephata*, Meyr., which may be distinguished by the small but distinct apical tuft on second joint of palpi, and the shorter terminal joint ($\frac{1}{3}$).

Queensland: Brisbane; taken abundantly on a fence in July, August, and September; all the examples are small (10-14 mm.). Coolangatta in September (♂ 15 mm.). Warwick in September (♂ 14 mm.). New South Wales: Sydney in October (♀ 18 mm.).

BATRACHEDRA MICRODRYAS, n.sp.

♂ ♀ 12-14 mm. Head ochreous-whitish. Palpi whitish; second joint with subapical, terminal joint with basal and apical fuscous

spots on external surface. Antennae ochreous-whitish. Thorax whitish-brown, darker in ♀.. Abdomen grey, darker in ♀; tuft whitish in ♂. Legs ochreous-whitish; tarsi with pale-grey annulations. Forewings narrow, apex pointed; whitish-brown, in ♀ rather darker; apical area with some fuscous suffusion, three pale costal spots, and an elongate blackish apical spot; cilia whitish-brown with a darker median line around apex. Hindwings nearly linear, cilia 10; grey; cilia grey.

Queensland: National Park (1,500 to 4,000 feet) in December, January, and March; nine specimens taken in dense jungle.

HAPLOCHROIS TANYPTERA, n.sp.

♂ 12-18 mm. Head and thorax fuscous-brown. Palpi moderately long, second joint with a minute apical tuft beneath, terminal joint about ⅓; whitish, apex of second joint except tuft and whole of terminal joint dark-fuscous. Antennae grey; basal joint fuscous-brown. Abdomen brown. Legs fuscous-brown. Forewings narrow; brown; a whitish costal streak from ¼ to apex; cilia brown. Hinderings narrow-lanceolate; grey; cilia grey.

Near *chlorometalla*, Meyr.

Queensland: Brisbane in October; Stradbroke Island in January; Coolangatta in September; three specimens.

COSMOPTERYX PHAESPHORA, n.sp.

♀ 8 mm. Head dark-fuscous; face pale-brassy. Palpi and antennae dark-fuscous. Thorax dark-fuscous; patagia shining-brassy. Abdomen and legs dark-fuscous. Forewings very narrow, apex acute; dark-fuscous; markings brilliant coppery-purple; costal line from base to ⅓, receding from costa at its posterior end; a second line, scarcely half as long, on fold beneath posterior half of first line; a moderately broad transverse median fascia; an inwardly oblique fascia from ¾ costa to tornus; a slender terminal line; cilia dark-fuscous with a white costal dot opposite second fascia and another on apex on dorsum grey. Hindwings linear-lanceolate; grey; cilia about 16, grey.

This exquisite species is allied to *mystica*, Meyr., but has only two basal lines.

Queensland: Brisbane in September; one specimen.

COSMOPTERYX CHALCELATA, n.sp.

♀ 10 mm. Head, palpi, and thorax fuscous. Antennae dark-fuscous; a broad apical and two subapical rings white. Abdomen fuscous. Legs fuscous; posterior pair with silver-white annulations. Forewings narrow, apex acute; dark-fuscous; three short parallel longitudinal silvery lines of nearly equal length, arranged in a transverse row at about ⅓; a pale coppery transverse fascia before middle; a similar incomplete fascia from tornus, not reaching costa; a similar costal spot at ¾; an elongate silvery apical spot; cilia dark-fuscous,

a white costal dot opposite costal spot, and a white apical streak. Hindwing narrow-lanceolate; grey; cilia 10, grey.

Also allied to *mystica*, but all the basal lines are short.

North Queensland: Kuranda, near Cairns; one specimen received from Mr. F. P. Dodd.

LABDIA SEMICOCCINEA, Sttn.

North Queensland: Townsville. Queensland: Brisbane.

LABDIA RHADINOPIS, n.sp.

♂ 12 mm. Head white. Palpi whitish; terminal joint with broad, nearly confluent, median, and apical fuscous rings. Antennae nearly 1; whitish, with three broad fuscous rings before apex. Thorax grey. Abdomen whitish-ochreous. Legs whitish; anterior pair fuscous. Forewings narrow; ochreous-grey; a broadly suffused, whitish, dorsal streak from near base to ⅔; a large white tornal spot, containing a central blackish dot, suffusedly prolonged and ochreous-tinged along termen; a very fine white line runs from beneath midcosta into tornal spot; white spots with blackish central dots on costa at ¾ and before apex, confluent with preceding; cilia whitish, on apex grey. Hindwings narrow-lanceolate; pale-grey; cilia pale-grey.

To the genus *Labdia* belong the majority of Australian species formerly referred to *Pyroderces*, from which genus they differ in the smooth forewings without any raised scales.

North Queensland: Kuranda near Cairns in September. Queensland: Coolangatta in October; three specimens.

LABDIA EUPHRANTICA, n.sp.

♀ 14 mm. Head orange-brown; face and three posterior dots on crown white. Palpi white; second joint with upper edge and subapical ring fuscous; terminal joint with basal, antemedian, and subapical blackish rings. Antennae black with white annulations, apex blackish preceded by a broad white, and this by a broad black ring. Thorax orange-brown. Abdomen orange-brown; terminal half of dorsum blackish. Legs fuscous annulated with white. Forewings narrow, apex acute; orange-brown, beyond middle bright orange; short, oblique, white, costal streaks at ⅙ and ⅓; similar streaks on fold at ⅙ and middle; the latter interrupts a median transverse fascia of fuscous and leaden-metallic scales; a similar very oblique fascia from ⅔ costa, sharply angled in disc, and bent back to tornus, where it is preceded by a white dot; a blackish apical streak; cilia orange, on apex blackish, on dorsum fuscous. Hindwings narrow-lanceolate; fuscous; cilia 8, fuscous.

Queensland: Mount Tambourine in November; one specimen.

LABDIA CROCOTYPA, n.sp.

♂ 10-12 mm. Head, palpi, and thorax whitish. Antennae whitish with fine fuscous annulations; apical fourth with three broad fuscous rings only. Abdomen pale-grey; base of dorsum orange-

ochreous. Legs whitish. Forewings narrow, apex pointed; whitish; markings orange-ochreous; two longitudinal streaks from base, one above, the other beneath fold, the former longer, extending to middle, sometimes interrupted; a short longitudinal streak beneath costa at about $\frac{2}{3}$, and another from beneath this to apex; cilia whitish, on dorsum pale-grey. Hindwings narrow-lanceolate; grey; cilia 8, pale-grey. Nearest *L. charisia*, Meyr.

North Queensland: Kuranda near Cairns; two specimens received from Mr. F. P. Dodd.

Labdia calthula, n.sp.

♂ 12 mm. Head white, on vertex ochreous-tinged. Palpi white. Antennae whitish, with a few blackish points towards apex. Thorax orange. Abdomen pale-grey. Legs whitish; anterior and middle tibiae and tarsi partly suffused with fuscous. Forewings narrow-lanceolate, orange; costa and dorsum narrowly yellow; cilia orange, on dorsum pale-grey. Hindwings narrow-lanceolate; pale-grey; cilia 8, pale-grey. Near *L. hierarcha*, Meyr.

North Queensland: Kuranda, near Cairns; one specimen received from Mr. F. P. Dodd.

Labdia orthoschema, n.sp.

♂ 10 mm. Head white. Palpi white; apex of terminal joint blackish. Antennae white. Thorax white; patagia blackish. Abdomen grey; tuft white. Legs fuscous with white annulations; middle tibiae, middle and posterior tarsi white. Forewings narrow, apex pointed; blackish with white markings; a well-defined costal streak from base to middle; an elongate costal spot from [illegible] to near apex; a dorsal streak from base to slightly beyond tornus, indented at tornus; cilia blackish, apices white except at apex, on costal spot white, on dorsum grey. Hindwings lanceolate; grey; cilia 6, grey.

Near *L. argophracta* but with costal streak broadly interrupted.

New South Wales: Glen Innes in December; one specimen.

Labdia mitrophora, n.sp.

♂ 10 mm. Head fuscous. Palpi fuscous; apex of terminal joint white. Antennae whitish annulated with dark-fuscous, in apical half some of these annulations are fused to form broader rings. Thorax and abdomen fuscous. Legs fuscous; tibiae and tarsi with white annulations. Forewings rather narrow, apex pointed; grey-whitish, markings fuscous mixed with reddish-brown; two short oblique streaks from costa near base, the second running into a quadrate blotch on dorsum near base; a moderate fascia slightly outwardly-oblique beyond middle, much dilated on costa, anterior edge ill-defined, posterior distinct and running to tornus; a subapical costal suffusion; an apical dark-fuscous spot; a fine leaden-metallic line near

and parallel to termen; cilia grey, on apex dark-fuscous. Hindwings lanceolate; grey; cilia 5, grey.

North Queensland: Kuranda near Cairns in October; two specimens received from Mr. F. P. Dodd.

Labdia ischnotypa, n.sp.

♂ 8 mm. Head grey-whitish. Palpi and antennae whitish. Thorax dark-fuscous. Abdomen grey. Legs whitish; anterior pair grey. Forewings narrow, apex acute; dark-fuscous; costal edge whitish from near base to near apex; a very fine, oblique, subcostal, whitish streak from ¾; a broad whitish dorsal streak continued on termen nearly to apex; cilia whitish, on apex dark-fuscous. Hindwings lanceolate; grey; cilia 6, grey.

North Queensland: Kuranda, near Cairns in June; one specimen.

Labdia argophracta, n.sp.

♂ 9-10 mm. Head ochreous-whitish. Palpi whitish; apex of terminal joint fuscous. Antennae whitish; basal joint dark-fuscous. Thorax ochreous-whitish with lateral blackish spots. Abdomen fuscous; tuft ochreous-whitish. Legs fuscous; middle and posterior tibiae and tarsi whitish; posterior tibiae fuscous at apex. Forewings blackish; an ochreous-whitish costal streak not quite reaching base and apex; a similar streak along dorsum and termen nearly to apex; cilia ochreous-whitish, on apex dark-fuscous. Hindwings and cilia grey.

Queensland: Warwick in October; Stanthorpe in October and February; six specimens.

Labdia hexaspila, n.sp.

♂ ♀ 10-12 mm. Head and thorax dark-fuscous; face whitish. Palpi whitish; apex of second joint and anterior edge of terminal joint fuscous. Antennae grey-whitish; basal joint fuscous. Abdomen fuscous; tuft ochreous-whitish. Legs dark-fuscous annulated with whitish. Forewings blackish; six white spots or streaks; first from ⅓ costa, narrow, elongate, outwardly oblique, reaching middle of disc; second and third on middle of costa and dorsum, nearly or quite confluent in disc; fourth on ¾ costa; fifth small, on dorsum before tornus; cilia fuscous, beneath apex a sixth white spot bisected by dark-fuscous, on dorsum grey. Hindwings and cilia grey.

Queensland: Brisbane in January, February and April.

New South Wales: Tabulam in December. Eight specimens.

Labdia ochrostephana, n.sp.

♂ ♀ 8-10 mm. Head pale ochreous-grey; face whitish. Palpi whitish; apex of second joint and anterior edge of terminal joint fuscous. Antennae grey. Thorax blackish. Abdomen grey. Legs dark-fuscous annulated with whitish. Forewings blackish; one fascia and four spots, white; fascia outwardly curved, oblique, from ⅓

costa to ⅓ dorsum, sometimes constricted in middle; spots on costa at middle and ¾, on dorsum at ⅔ and tornus, the last minute or absent; sometimes a dot at apex; cilia whitish, fuscous at bases around apex, at extreme apex fuscous also at apices, on dorsum grey. Hindwings and cilia grey.

Very near *myrrhicoma*, Meyr., which I have also from Brisbane, differing only in the sub-basal fascia. I suspect they may be forms of one species.

Queensland: Brisbane in October, December, and March.

New South Wales: Tabulam in December. Twelve specimens.

LABDIA ANCYLOSEMA, n.sp.

♂ 12 mm. Head pale ochreous-brown. Palpi whitish; terminal joint fuscous anteriorly. Antennae blackish. Thorax blackish. Abdomen fuscous. Legs blackish annulated with white. Forewings moderate, apex obtuse; blackish; markings white; a transverse fascia at about ⅙ angled outwards in middle, anterior border indented, posterior rather acutely projecting; a second fascia beyond middle, interrupted in mid-disc; a costal subapical spot, and a spot beneath on termen; cilia blackish, on dorsum grey. Hindwings broadly lanceolate; grey; cilia 3, grey.

Near *ochrostephana* but the sub basal fascia is very differently formed.

Northern Territory: Darwin in March; one specimen received from Mr. F. P. Dodd.

LABDIA TRISTOECHA, n.sp.

♂ 9 mm. Head grey; face ochreous-whitish. Palpi ochreous-whitish; apex of second joint, and terminal joint except base, fuscous. Antennae blackish with ochreous-whitish annulations. Thorax fuscous. Abdomen fuscous; tuft ochreous-whitish. Legs fuscous annulated with ochreous-whitish. Forewings rather narrow, apex rounded; fuscous; markings ochreous-whitish; a moderate fascia from ⅙ costa to ¼ dorsum, broadest on costa, slightly curved outwards; a broader fascia from midcosta to beyond mid-dorsum, strongly indented anteriorly, projecting and ill-defined posteriorly; a dark-fuscous dot in disc beyond this; a large costal subapical spot, with a smaller tornal spot opposite; a terminal line; cilia whitish with a median line dark-fuscous and apices fuscous, on tornus wholly whitish, on dorsum grey. Hindwings lanceolate; grey; cilia 6, grey.

Near *L. trivincta*, Meyr., but forewings paler with dark postmedian spot, a second fascia, ill-defined posteriorly, and termen whitish.

North Queensland: Townsville in September; one specimen.

LABDIA RHOECOSTICHA, n.sp.

♂ 10 mm. Head and thorax dark-fuscous. Palpi fuscous. Antennae fuscous with four or five narrow whitish rings in terminal half. Abdomen dark-fuscous. Legs fuscous; middle and posterior pairs with obscure whitish annulations. Forewings narrow, apex

rounded; dark-fuscous; markings shining white; an oblique line from ⅓ costa reaching fold; two dots in disc beyond this, placed obliquely, the lower one on fold; a squarish spot on midcosta, from its anterior angle a fine oblique line to ⅔ dorsum, there bent at a right angle very obliquely outwards, in lower part of disc again bent at a right angle so as to be parallel to its former direction for a short distance, curved outwards just before its termination in middle of disc; a spot on ¾ costa; a fine short erect line from tornus; an apical dot; cilia fuscous, on dorsum grey. Hindwings lanceolate; grey; cilia 4, grey.

Queensland: Mount Tambourine in November; one specimen.

Labdia triploa, n.sp.

♂ 10 mm. Head ochreous-white. Palpi whitish. Antennae grey. Thorax fuscous. Abdomen grey. Legs pale-fuscous; middle and posterior pairs obscurely annulated with whitish. Forewings narrow, apex pointed; pale brassy-fuscous; markings ochreous-white; a large spot on ¼ dorsum, rounded, with a narrow pointed apex extending above fold; a moderate oblique fascia from midcosta to ¾ dorsum; a triangular subapical costal spot; cilia pale-fuscous, on dorsum grey. Hindwings lanceolate; pale-grey; cilia 8, pale-grey.

North Queensland: Kuranda near Cairns in October; one specimen.

Labdia niphostephes, n.sp.

♂ ♀ 8-9 mm. Head white. Palpi white; second joint with basal and subapical, terminal joint with basal and apical blackish rings. Antennae dark-fuscous with some whitish rings about ¼, middle, and towards apex. Thorax whitish. Abdomen grey. Legs blackish, sharply annulated with white. Forewings narrow, apex rounded; blackish; a grey basal patch not reaching costa; a moderate oblique fascia from ⅓ costa broadening to ⅓ dorsum, on costa white, but mostly suffused with grey; a similar fascia from midcosta to beyond mid-dorsum; a triangular, white, subapical costal spot sometimes connected with a white dot on midtermen; cilia whitish, bases and an apical hook fuscous, on dorsum grey. Hindwings lanceolate; grey; cilia 6, grey.

Queensland: Brisbane, in October; two specimens.

Labdia niphocera, n.sp.

♂ 12 mm. Head white. Palpi grey; internal surface except towards apex whitish. Antennae white, towards apex greyish; basal joint thickened. Thorax white, patagia fuscous. Abdomen grey. Legs whitish; anterior pair fuscous. Forewings lanceolate; brownish-fuscous; a dark-fuscous elongate spot about middle above dorsum; an oval dark-fuscous median spot at ⅔ preceded and followed by an ill-defined median dark streak; a whitish dorsal streak from base, indented at tornus, continued along termen to apex; cilia grey, on costa and apex fuscous. Hindwings lanceolate; grey; cilia 5, grey.

North Queensland: Kuranda near Cairns in September; one specimen received from Mr. F. P. Dodd.

LABDIA PANTOPHYRTA, n.sp.

♀ 9 mm. Head grey-whitish. Palpi whitish. Antennae whitish, towards apex finely annulated with grey. Thorax pale-ochreous; patagia grey. Abdomen grey. Legs fuscous; middle and posterior tibiae and tarsi annulated with whitish. Forewings narrow, apex pointed; pale-ochreous; markings fuscous; a rather large basal patch; a broad internally-oblique antemedian fascia containing some pale-ochreous scales, its edges irregular; an apical costal spot; cilia on costal spot fuscous, on costa before this whitish, on apex pale-ochreous, on termen and dorsum grey. Hindwings narrow-lanceolate; grey; cilia 6, grey.

North Queensland: Innisfail in November; one specimen.

LABDIA LEUCONOTA, n.sp.

♂ 7-8 mm. Head white; crown ochreous-tinged. Palpi white; second joint greyish. Antennae white; basal joint thickened. Thorax white; patagia dark-fuscous. Abdomen fuscous. Legs fuscous; middle and posterior pairs whitish on inner surface, and with whitish bands on tibiae and tarsi. Forewings narrow, apex obtuse; dark-fuscous; a broad white dorsal streak, indented at tornus, continued on termen to apex; slight white marks on costa at middle and ¾; cilia whitish, bases dark-fuscous on termen, on costa and apex wholly dark-fuscous. Hindwings narrow-lanceolate; grey; cilia 6, grey.

Queensland: Brisbane and Rosewood in April; two specimens.

LABDIA ZONOBELA, n.sp.

♀ 9 mm. Head white. Palpi white; second and terminal joints with sub-basal and subapical dark-fuscous rings. Antennae dark-fuscous with two whitish rings at about ⅗. Thorax grey-whitish. Abdomen grey. Legs fuscous; middle and posterior tarsi with whitish annulations. Forewings narrow, obtuse; dark-fuscous; a white dorsal streak, containing some brownish irroration, indented near base and at middle, continued on termen nearly to apex; ill-defined whitish costal spots at middle and ¾; cilia whitish, on costa and apex dark-fuscous. Hindwings narrow-lanceolate; grey; cilia 7, grey.

Not unlike the preceding, but easily distinguished by the palpi and antennae. They appear to be allied to *oxysema*, Meyr.

Queensland: Crow's Nest, near Toowoomba, in March; one specimen.

LABDIA PAMMECES, n.sp.

♂ 22 mm. Head pale-ochreous; face fuscous. Palpi fuscous; second joint slightly roughened anteriorly. Antennae fuscous, apical sixth white. Thorax fuscous. Abdomen pale-ochreous (partly broken). Forelegs fuscous, tarsi whitish except at apex; (middle and posterior pairs broken off). Forewings elongate, apex pointed; fuscous with

sparse pale-ochreous irroration; three pale-ochreous transverse fasciae; first sub-basal, broad, not reaching costal edge; second moderate at one-third; third narrower from two-thirds costa to tornus, where it expands; cilia fuscous, on tornus whitish-ochreous. Hindwings lanceolate; grey; cilia 4, ochreous-grey.

Northern Territory: Darwin (Dodd); one specimen.

North Queensland: Claudie River (Kershaw); one specimen.

PYRODERCES ANACLASTIS, Meyr.

Hitherto an extreme rarity, for I had only taken two examples in 25 years, one of them being the type specimen, this species has been bred in large numbers by Mr. G. H. Hardy from the hanging paper nests of the wasp *Polistes variabilis Saussure*, which is common in Brisbane gardens. Several scores were obtained from two nests, one of which was given me for examination. I found the pupae in small cocoons of white silk spun on the sides of the hexagonal cells. No larvae were seen, but I think they will prove to be feeders on dry rubbish, The marginal cells contained many living uninjured wasp eggs, larvae, and pupae. The moth larvae had left their traces in the form of silken threads and excreta in the central cells, which may have been empty before they invaded them.

To *Pyroderces* should be referred also *mesoptila*, Meyr., *terminella* Wlk., *pyrrhodes*, Meyr., and *aulacosema* Low.. P. *anaclastis* is best distinguished by the large median fuscous patch of raised scales resting on dorsum, and the tuft of hairs from near base of dorsum of hindwings on underside in ♂.

PYRODERCES TERMINELLA, *Wlk.*

With the preceding and following species this forms a group which requires very careful discrimination; it may be best distinguished by the inwardly oblique fuscous line in disc between midcosta and mid-dorsum, and by the short tuft on base of dorsum of hindwings in ♂.

PYRODERCES FALCATELLA, Sttn.

This name was attached by Mr. Meyrick to a specimen I sent him from Townsville, and he informed me that *spodochtha*, Meyr., was a synonym. I do not think *dendrophaga*, Meyr. (Exot. Micro. II. p. 318) can be separated from this species, which varies in the intensity of the dark irroration of its whitish markings, their ground colour being sometimes much obscured.

North Queensland: Cardwell, Townsville.

Queensland: Brisbane, Toowoomba, Dalby, Charleville. Also from India.

PYRODERCES POGONIAS, n.sp.

♂ ♀ 14-16 mm. Head whitish, median area sometimes fuscous. Palpi with an inferior apical tuft on second joint as long as terminal joint; whitish; second joint brownish except at base and apex; terminal joint blackish at apex. Antennae fuscous. Thorax brown. Ab-

domen grey; dorsum more or less brown; tuft whitish. Legs fuscous annulated with whitish. Forewings lanceolate, apex acute; brown; an outwardly oblique fascia; ill-defined posteriorly, from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, connected in disc with a similar transverse median fascia, which does not quite reach costa, but is prolonged as a subcostal streak nearly to apex; a fine whitish line on fold from base to first fascia; a spot or short longitudinal streak above tornus, blackish mixed and surrounded with whitish; cilia brown with a longitudinal blackish bar running to apex, and another short bar beneath at right angles, on dorsum grey. Hindwings narrow-lanceolate; grey; cilia 10; grey.

Resembles *P. terminella*, Wlk., and *falcatella*, Sttn., but at once distinguished by the long-tufted palpi.

New South Wales: Sydney; two specimens with a curious history. Dr. R. J. Tillyard collected, at Epping near Sydney, twigs of *Acacia decurrens*, infested with Neuroptera, which he desired to introduce into New Zealand for economic purposes. From these twigs this with other species of Lepidoptera emerged in New Zealand in November, and were sent to me by Mr. A. J. Philpott, of the Cawthron Institute.

PYRODERCES HAPALODES, n.sp.

♂ 8 mm. Head whitish. Palpi whitish; second joint with subapical, terminal joint with sub-basal and subapical blackish rings. Antennae ochreous-whitish with blackish annulations, which towards apex are arranged in groups of three. Thorax whitish-brown. Abdomen grey; tuft whitish-ochreous. Legs ochreous-whitish; anterior and middle pairs with blackish annulations. Forewings moderate, apex obtuse; pale-brown with a few blackish scales; blackish discal dots at middle and $\frac{3}{4}$; short blackish streaks on costa from base, at $\frac{1}{3}$ and at $\frac{2}{3}$; cilia pale-grown with blackish points, on dorsum whitish-ochreous. Hindwings lanceolate; pale-grey; cilia 8, pale-grey.

Queensland: National Park (3,000 ft.) in January; one specimen.

PYRODERCES TENUILINEA, n.sp.

♂ ♀ 6-7 mm. Head whitish. Palpi moderate; second joint with a slight apical tuft; terminal joint $\frac{2}{3}$; whitish. Antennae ochreous-whitish; in ♂ with joints strongly expanded at apices. Thorax, abdomen, and legs ochreous-whitish. Forewings narrow. apex pointed; ochreous-whitish with patchy brownish suffusion and very slender, interrupted, blackish lines; a subcostal line from base to $\frac{1}{3}$; a line from base along fold to mid-dorsum; a short line in mid-disc beyond middle; another less distinct beneath apical third of costa running into costal cilia; cilia ochreous-whitish, with transverse bar and apical dot blackish, towards dorsum grey. Hindwings linear-lanceolate; grey; cilia grey.

Queensland: Sandgate near Brisbane in September; three specimens.

STAGMATOPHORA NOTOLEUCA, n.sp.

♂ ♀ 8-9 mm. Head and palpi whitish. Antennae grey-whitish; basal joint fuscous. Thorax whitish; patagia mostly fuscous. Legs whitish with some fuscous admixture; anterior pair fuscous. Forewings narrow; fuscous; markings whitish; a dorsal streak from base to $\frac{2}{3}$; a costal spot at $\frac{1}{4}$; a median costal spot, narrowly confluent with a spot on dorsum before tornus; a subapical costal spot; a small spot on termen above tornus; cilia whitish with a fuscous bar opposite apex. Hindwings narrow-lanceolate; pale-grey; cilia pale-grey.

Mr. Meyrick informs me that *Stagmatophora* differs from *Labdia* and *Pyroderces* in 7 and 8 being stalked out of 6, in the latter they arise separately from 6. To it are referred *oxytoma*, Meyr., *autotoma*, Meyr., *tetradesma*, Meyr., *argyrostrepta*, Meyr., and *clinarcha*, Meyr.

Queensland: Dalby in April. New South Wales: Glen Innes in March. Four specimens.

LIMNOECIA ORTHOCHROA.

Aeoloscelis orthochroa, Low, P.L.S., N.S.W., 1899, p. 113.

New South Wales: Broken Hill.

LIMNOECIA PLATYOCHRA, n.sp.

♀ 7-10 mm. Head whitish. Palpi with second joint slightly roughened towards apex; whitish; external surface of second joint with basal half and a subapical bar blackish; terminal joints with sub-basal and subapical blackish rings. Antennae whitish; base, a broad ring at $\frac{3}{4}$, and some finer annulations blackish. Thorax ochreous-whitish. Abdomen grey. Legs whitish annulated with dark-fuscous; anterior pair dark-fuscous. Forewings narrow, pointed, blackish; markings whitish or brown-whitish; a dorsal streak throughout, broad towards base, continued to apex, joined by broad oblique fasciae from $\frac{1}{4}$ and mid-costa; a triangular costal spot before apex; cilia brown-whitish with a few dark-fuscous spots around apex. Hindwings linear-lanceolate, cilia 6; grey; cilia grey.

Queensland: Brisbane in August, October, and January; four specimens.

LIMNOECIA ELAPHROPA, n.sp.

♂ 9 mm. Head grey. Palpi smooth; whitish; second joint with subapical, terminal joint with basal and subapical fuscous bars on external surface. Antennae whitish with fine fuscous annulations, base and a broader ring at $\frac{3}{4}$ fuscous. Thorax white. Abdomen pale-grey. Legs whitish; anterior and middle pairs with fuscous annulations. Forewings rather narrow, pointed; white; markings fuscous; an oblique line from near base of costa to $\frac{1}{4}$ dorsum; a large wedge-shaped spot on $\frac{1}{3}$ costa, its apex reading half across disc; a second oblong spot on $\frac{2}{3}$ costa, with a blackish dot beneath it; an elongate spot at apex; cilia white with a fine fuscous median line around apex. Hindwings linear-lanceolate, cilia 5; pale-grey; cilia whitish.

Queensland: Coolangatta in September; one specimen.

LIMNOECIA PALLIDULA, n.sp.

♂ 12 mm. Head white. Palpi with second joint slightly rough in front; whitish; second joint with basal and apical, terminal with basal and subapical pale-fuscous bars on external surface. Antennae pale-fuscous. Thorax white. Abdomen ochreous-whitish; base of dorsum ochreous. Legs ochreous-whitish; anterior and middle pairs annulated with pale-fuscous. Forewings rather narrow, acute; ochreous-whitish; markings very pale fuscous; a basal patch, obsolete towards dorsum, its outer edge oblique; a wedge-shaped patch on costa before middle, nearly or quite bisected by a fine longitudinal whitish line; an oblong patch on costa at ⅔, slightly darker; a slight apical suffusion, cilia ochreous-whitish. Hindwings lanceolate, cilia 3½; pale-grey; cilia whitish.

Queensland: Brisbane in November; one specimen.

LIMNOECIA CIRRHOSEMA, n.sp.

♂ 15 mm. Head yellowish-white. Palpi smooth; fuscous; second joint except basal ¼ whitish. Antennae fuscous. Thorax blackish. Abdomen pale-ochreous with several fuscous rings towards apex. Legs ochreous-whitish annulated with fuscous. Forewings narrow, pointed; blackish; three yellowish-white fasciae; first before ¼, broad, transverse, narrowing on dorsum; second beyond middle transverse, dilated in middle, sometimes not reaching dorsum; third from costa before apex to termen, narrow, slightly inwardly-oblique; cilia dark-fuscous. Hindwings lanceolate; grey; cilia 3, grey.

Queensland: Toowoomba; one specimen received from Mr. W. B. Barnard.

LIMNOECIA ORBIGERA, n.sp.

♂ 18-19 mm. Head white. Palpi with second joint dilated with rough scales; white; extreme base and apex blackish. Antennae blackish with broad white rings on middle and at apex. Thorax blackish. Abdomen pale-ochreous, on sides fuscous. Legs blackish; tarsi with white annulations. Forewings moderate, apex obtuse; blackish; markings white; a large roundish sub-basal spot from costa not quite reaching dorsum; a second roundish spot in disc touching midcosta; a subapical costal dot, and another on tornus; cilia fuscous, on apex white. Hindwings lanceolate; grey; cilia 2, grey.

Queensland: Brisbane in November and February; two specimens.

LIMNOECIA CIRRHOZONA, n.sp.

♂ ♀ 18-20 mm. Head brownish (unfortunately badly rubbed). Palpi smooth; blackish. Antennae blackish; a white ring in middle and another broader at apex. Thorax blackish. Abdomen pale-grey, towards apex dark-fuscous. Legs blackish; tarsi white annulations. Forewings moderate, apex rounded; blackish; a broad, transverse, sub-basal, pale-ochreous fascia; a white tranverse line from midcosta not reaching dorsum; a white line from ¾ costa to tornus, con-

stricted in middle; cilia dark-fuscous, on apex white. Hindwings lanceolate; grey; cilia 2, grey.

Queensland: Brisbane; one specimen. W.A.: Perth; two specimens received from Mr. L. J. Newman.

LIMNOECIA LEUCOMITA, n.sp.

14 mm. Head, thorax, palpi, and antennae dark-fuscous. Palpi smooth. Abdomen grey. Legs grey; tarsi with whitish annulations. Forewings narrow, apex pointed; dark-fuscous; markings white; a very fine oblique line from ⅙ costa to ⅓ dorsum; a similar line from midcosta to ⅔ dorsum; a spot on ¾ costa; a very slender erect mark from termen above tornus; cilia dark-fuscous, on dorsum grey. Hindwings narrowly lanceolate; grey; cilia 5, grey.

Queensland: Brisbane; one specimen.

LIMNOECIA PLATYSCIA, n.sp.

♂ ♀ 10-12 mm. Head fuscous; face whitish. Palpi smooth; white; a penultimate ring on second joint and outer surface of terminal joint blackish. Antennae blackish annulated with white. Thorax fuscous. Abdomen grey. Legs dark-fuscous annulated with white; posterior pair mostly white. Forewings moderate, apex rounded; fuscous; finely and evenly irrorated with white; three white transverse fasciae, sub-basal, median, and subapical, unevenly margined; a blackish discal dot shortly before middle, a second beneath it on fold, a third beyond middle, and a fourth beyond and in line with third; a blackish apical spot; termen white with a few marginal blackish scales; cilia white with a blackish median line, on dorsum grey. Hindwing linear-lanceolate; grey; cilia 6, grey.

Queensland: Warwick in November; two specimens.

LIMNOECIA SYMPLECTA, n.sp.

♂ ♀ 10-12 mm. Head pale-grey with darker points; posterior edge of crown white. Palpi whitish irrorated with blackish, not distinctly ringed. Antennae dark-fuscous. Thorax dark-fuscous with fine white irroration. Abdomen grey; beneath whitish. Legs fuscous; anterior and middle pairs annulated with whitish. Forewings narrow, apex round-pointed; fuscous with some whitish irroration; ill-defined whitish spots on costa at ⅓, ⅔, and ¾; a whitish suffusion along dorsum, interrupted or indented at ¼; a blackish streak from base along fold to ¼, there angled to beneath ⅓ costa, where it touches a longitudinally oval blackish discal spot which is closely followed by a similar spot at ⅔; cilia fuscous, on dorsum grey. Hindwings rather broadly lanceolate; grey; cilia 2½, grey.

Queensland: Brisbane in August; two specimens.

LIMNOECIA ADIACRITA, n.sp.

♀ 10-11 mm. Head brownish. Palpi smooth; whitish; two pale-fuscous rings on second, and two on terminal joint. Antennae whit-

ish with more or less distinct fuscous annulations. Thorax brown. Abdomen grey. Legs fuscous; posterior pair ochreous-whitish irrorated with fuscous. Forewings narrow, apex pointed; brown with some fuscous irroration and fuscous dots; a series of minute costal dots; a sub-basal discal spot; a longitudinally elongate spot in disc beyond middle; another discal spot at $\frac{4}{5}$; cilia fuscous. on dorsum grey. Hindwings linear-lanceolate; grey; cilia 8, grey.

Queensland: Brisbane and Coolgangatta in August; Charleville in September: five specimens.

LIMNOECIA LEPTOZONA, n.sp.

♀ 13 mm. Head fuscous; face ochreous-whitish. Palpi fuscous; second joint broadly ochreous-whitish in middle. Antennae fuscous, extreme apex whitish. Thorax brown-whitish with a large posterior fuscous spot. Abdomen grey. Legs fuscous annulated with whitish. Forewings moderate, obtuse; fuscous; three ill-defined narrow transverse brown-whitish fasciae; first at $\frac{1}{5}$; second at middle expanded in disc, and sometimes containing a fuscous dot; third from $\frac{3}{4}$ costa to tornus, interrupted in middle; a brown-whitish apical dot; cilia grey. Hindwings lanceolate; grey; cilia 5, grey.

Queensland: Brisbane in November; one specimen.

LIMNOECIA HEMIMITRA, n.sp.

♂ 12 m.m. Head and thorax dark-fuscous. Palpi fuscous; second joint with postmedian and apical, terminal joint with subbasal whitish rings. Antennae fuscous, towards apex whitish. (Abdomen missing.) Legs fuscous with whitish annulations. Forewings moderate, apex pointed; dark-fuscous; markings white; a broad outwardly oblique line from $\frac{1}{5}$ costa, ending in a point just beyond fold; a spot on midcosta; another on dorsum before tornus; a third on costa before apex; cilia fuscous, on dorsum grey. Hindwings broadly lanceolate; grey; cilia 4, grey.

Queensland: Brisbane in September; one specimen.

HOPLOPHANES CHALCOPHAEDRA, n.sp.

♂ 18 mm. Head ochreous; face fuscous. Palpi pale-ochreous. Antennae fuscous. Thorax brassy-fuscous. Abdomen fuscous; tuft ochreous. Legs fuscous; posterior tibiae and tarsi ochreous. Forewings elongate-oval, apex tolerably pointed; golden-brassy; cilia fuscous, bases golden-brassy. Hindwings broadly lanceolate; fuscous; cilia $1\frac{1}{2}$, ochreous, on costa and apex fuscous.

New South Wales: Glen Innes in April; one specimen.

ORTHOMICTA ARGONOTA, n.sp.

♀ 14 mm. Head whitish. Palpi pale grey; second joint slightly thickened and roughened anteriorly; terminal joint stout. Antennae grey; basal joint much thickened, grey-whitish. Thorax grey-whitish. Abdomen grey; towards base grey-whitish. Legs fuscous; posterior

pair whitish. Forewings rather narrow, apex obtuse; grey; a broad white dorsal streak; a large fuscous triangle on mid-costa, its apex reaching beyond middle, edged posteriorly by a whitish line; a fuscous suffusion on lower half of termen; a fascia from $\frac{5}{6}$ costa to termen above middle, widening towards termen, brownish, edged posteriorly by a whitish line, beyond which is some fuscous suffusion; cilia grey, on costa and apex fuscous. Hindwings lanceolate; grey; cilia 3, grey.

Queensland: Mt. Tambourine in March; one specimen.

ORTHROMICTA SEMIFUMEA, n.sp.

♂ 12-13 mm. Head white. Palpi white; second joint fuscous on external surface, slightly dilated with anterior rough scales towards apex. Antennae grey; basal joint much thickened, white. Thorax white. Abdomen grey. Legs fuscous; posterior pair grey. Forewings rather narrow, apex pointed; grey; basal area except on dorsal side of fold suffused with fuscous to beyond middle; a transverse ridge of raised scales in disc at $\frac{2}{3}$, and another slightly before it running to dorsum; postmedian area pale but becoming darker posteriorly; an obscure series of submarginal fuscous dots on terminal part of costa and apex; cilia grey. Hindwings lanceolate; grey; cilia 4, grey.

Queensland: Brisbane in September, November, and February; Rosewood in September; four specimens.

SYNTOMACTIS PYGAEA, n.sp.

♀ 18 mm. Head ochreous-white. Palpi fuscous; second joint with strong acute anterior tuft before apex, on outer surface at apex, and on inner surface except base, whitish; terminal joint with some whitish irroration, very long. Antennae blackish. Thorax ochreous-white; patagia blackish. Abdomen with first four segments on dorsum pale-ochreous, remainder blackish, beneath whitish. Legs blackish; middle and posterior pairs annulated with pale-ochreous. Forewings rather narrow, apex obtuse; dark-fuscous; a grey dorsal suffusion beyond middle; six or seven prominent transverse ridges of raised scales; cilia grey, on dorsum ochreous in basal halves. Hindwings lanceolate; grey; cilia 4, pale-ochreous, apices grey, on costa and apex wholly grey.

Queensland: Brisbane in January; one specimen.

SYNTOMACTIS MACROSTOLA, n sp.

♀ 25-30 mm. Head grey-whitish with a few fuscous scales. Palpi fuscous; second joint thickened with four ridges of scales in distal half, and with a small anterior apical tuft, sub-basal and median grey-whitish rings; terminal joint stout, basal, antemedian, postmedian, and apical rings grey-whitish. Antennae grey-whitish with blackish dorsal bars; basal joint elongate, fuscous. Thorax grey-whitish with more or less dark-fuscous irroration; centre of patagia dark-fuscous. Abdomen fuscous; dorsum of first two or three seg-

ments and underside grey-whitish. Legs dark-fuscous annulated with grey-whitish. Forewings elongate, apex pointed; grey-whitish more or less irrorated or suffused with fuscous; a blackish subcostal streak from base to ⅓, sometimes edged beneath with brownish; a broader streak from base along fold, sometimes lost in fuscous suffusion; several fine longitudinal blackish streaks in mid-disc and on veins in terminal area; many sharply raised transverse ridges of scales; cilia grey, on costa and apex fuscous. Hindwings lanceolate; grey; cilia 2, grey.

The presence of tufts on the apices of second joints of the palpi does not appear to be a good generic character in this family, and I have therefore merged *Trachydora*, Meyr., with *Syntomactis*, Meyr.

Queensland: Brisbane and Blackbutt in January; three specimens.

Syntomactis fumea, n.sp.

♀ 29 mm. Head fuscous. Palpi whitish; second joint with five transverse fuscous lines on external surface, and a long acute fuscous apical tuft; terminal joint very slender. Antennae fuscous. Thorax and abdomen fuscous. Legs whitish; anterior pair fuscous; middle tibiae annulated with fuscous, tarsi fuscous; posterior tibiae with an oblique median bar and apex fuscous on external surface, tarsi annulated with fuscous. Forewings moderate, apex pointed; uniformly fuscous; five transverse ridges of raised scales; first above ¼ dorsum, second and third approximated above mid-dorsum, fourth and fifth forming a nearly continuous ridge from tornus to ⅚ costa; cilia fuscous. Hindwings broadly lanceolate; grey; cilia 2, grey.

Queensland: Sandgate near Brisbane in September; one specimen.

Syntomactis acrocyrta, n.sp.

♂ 16 mm. Head ochreous-whitish. Palpi ochreous-whitish; second joint with long projecting scales above and beneath, the latter forming a small apical tuft, the former irrorated with fuscous; terminal joint with 3 or 4 obscure fuscous rings. Antennae fuscous, towards base grey. Thorax grey; patagia whitish with a central brown stripe. Abdomen brownish-grey, beneath whitish. Legs whitish; middle tibiae with two oblique fuscous bars on external surface; [posterior pair missing]. Forewings rather narrow, apex acutely produced and slightly hooked, termen sinuate; brownish-grey; a broad ochreous-whitish costal suffusion containing four oblique ochreous-brown lines, first from base, second from before middle, third from ¾, fourth subapical; five transverse ridges of raised scales, fuscous preceded by ochreous-brown spots; third costal line becomes fuscous in disc and is prolonged to termen beneath apex; cilia grey-whitish, on costa with bases fuscous, a fuscous bar at apex. Hindwings lanceolate; brownish-grey, paler towards base; cilia 4, grey.

Queensland: Brisbane in November; one specimen.

Syntomactis tephronota, n.sp.

♂ 10 mm. Head grey-whitish. Palpi grey, towards base fuscous; tuft as long as terminal joint, finely ridged, being composed

of many fine conglomerate tufts. Antennae fuscous. Thorax grey-whitish; bases of patagia fuscous. Abdomen grey. Legs fuscous with whitish annulations; posterior mostly whitish. Forewings narrow, apex pointed; fuscous; a broad pale-grey dorsal streak, towards base limited by fold; a supratornal grey-whitish blotch containing 3 or 4 fine transverse fuscous strigulae; a dark-fuscous subapical spot; cilia grey. Hindwings lanceolate; grey; cilia 5, grey.

Queensland: Brisbane in November; one specimen.

SYNTOMACTIS ACROMIANTA, n.sp.

♂ 15 mm. Head brownish-grey. Palpi grey; second joint ridged and expanded towards apex, but not tufted; terminal joint as long as second, slender, with basal, ante-median, and postmedian whitish rings. Thorax brownish-grey; bases of patagia brownish. Abdomen fuscous. Legs grey. Forewings moderate, pointed; grey; short fuscous streaks on costa near base, $\frac{1}{3}$, and middle; a sub-basal fuscous blotch preceded and followed by a transverse ridge of raised scales; apical area suffused with orange-brown, and transversed by a series of interneural fuscous streaks; an apical fuscous dot; cilia grey, on apex fuscous. Hindwings broadly-lanceolate; dork-grey; cilia $2\frac{1}{2}$, grey.

Queensland: Brisbane in November; one specimen.

SYNTOMACTIS CRASSIPALPIS, n.sp.

♂ 12 mm. Head pale-grey with a few darker points. Palpi fuscous; second joint with basal, postmedian, and apical whitish rings, expanded at apex but not tufted; terminal joint $\frac{2}{3}$, stout, acute, with antemedian and postmedian whitish rings. Thorax pale-grey. Abdomen grey. Legs fuscous annulated with whitish; hairs on posterior tibiae ochreous-whitish. Forewings narrow, pointed; fuscous-grey with some fine blackish irroration, more abundant towards apex; apices of transverse ridges whitish; a suffused whitish costal spot at $\frac{3}{4}$, another on termen above tornus, and a third beneath apex; cilia on and beneath apex fuscous with a whitish basal line and apical points, on lower termen and dorsum grey. Hindwings narrowly lanceolate; grey; cilia 6, pale grey.

Queensland: Mount Tambourine in November; two specimens.

SYNTOMACTIS SPODOPTERA, n.sp.

♀ 10-12 mm. Head and thorax grey finely irrorated with whitish. Palpi whitish-grey with fine blackish rings; second joint expanded at apex but not tufted, three dark rings before apex; terminal joint, slender, with three pairs of dark rings, which may be partly fused. Antennae grey with fine whitish annulations. Abdomen and legs grey. Forewings rather narrow, round-pointed; grey with fine whitish irroration; transverse ridges dark-fuscous, but whitish at apices; cilia grey, on apex and upper part of termen with fine whitish points. Hindwings broadly lanceolate; grey; cilia 8, grey.

Queensland: Stradbroke Island in September; two specimens.

MICROCOLONA SPANIOSPILA, n.sp.

♂ 6 mm. Head ochreous-whitish. Palpi whitish; second joint with subapical, terminal joint with sub-basal and subapical fuscous rings. Antennae whitish. Thorax whitish-ochreous. Abdomen ochreous-whitish. Legs whitish; anterior pair and apices of middle and posterior tarsi fuscous. Forewings rather narrow, apex obtuse; pale-brown; dots of raised scales blackish with pale outlines; a large dot above ¼ dorsum, a minute dot beneath ⅓ costa, a dot on ⅔ costa, and another above tornus; some fine blackish irroration in apical part of disc and on dorsum towards base; cilia whitish-ochreous, on dorsum towards base; cilia whitish-ochreous, on dorsum pale-grey. Hindwings almost linear; grey; cilia over 12, pale-grey.

North Queensland: Kuranda near Cairns in October. Queensland: Eumundi near Nambour in December. Three specimens.

ELACHISTA EGENA, n.sp.

♂ 10-14 mm. Head, palpi, and thorax whitish. Antennae pale-grey, towards base whitish. Abdomen ochreous-whitish. Legs pale-fuscous; posterior pair ochreous-whitish. Forewings moderate, costa gently arched; ochreous-whitish with a few fuscous scales; a blackish dot on fold at about middle of disc; another in disc at ¾; cilia ochreous-whitish. Hindwings lanceolate; pale-grey; cilia pale-grey.

Quensland: Brisbane, Stradbroke Island in August; Killarney in October. New South Wales: Adaminaby in October. Four specimens.

ELACHISTA APHANTA, n.sp.

♂ 6-9 mm. Head fuscous; face whitish. Palpi whitish. Antennae fuscous. Thorax and addomen fuscous. Legs grey; tarsi obscurely annulated with whitsih. Forewings with apex obtuse; fuscous; a darker transverse fascia from costa before middle to dorsum beyond middle, immediately preceded by a more or less developed whitish fascia; a whitish spot on ⅔ costa, sometimes confluent with a similar spot on termen; cilia fuscous, with a whitish subapical spot and a dark fuscous terminal line, on dorsum grey. Hindwings lanceolate; grey; cilia 6, grey.

Queensland: Brisbane in October, November, and December. Stradbroke Island in August. Toowoomba in September. Bunya Mts. (3500 ft) in October. Killarney in October.

New South Wales: Tenterfield in August. Ben Lomond (4,500 ft.) in January. Sydney in August. Eighteen specimens.

Gen. PHANEROCTENA, nov.

Head with appressed hairs. Tongue developed. Labial palpi moderately long, recurved, ascending, smooth; terminal joint shorter than second, acute. Maxillary palpi obsolete. Antennae ⅘; in ♂ very shortly ciliated; basal joint moderate, with strong pecten. Posterior tibiae clothed with long hairs. Forewings with 6 and 7 stalked, 7 to costa, 11 from middle. Hindwings lanceolate; 6 and 7 stalked.

Allied to *Elachista*, from which it is distinguished by the antennal pecten. Type *P spodopasta.*

Phaneroctena spodopasta, n.sp.

♂ ♀ 11-12 mm. Head, antennae, and thorax pale-grey. Palpi whitish; second joint with broad subapical fuscous ring; terminal joint with median fuscous ring. Abdomen and legs grey. Forewings narrow, apex rather obtusely pointed; in ♂ with a small expansile tuft of hairs from base of costa beneath; whitish rather densely irrorated with grey throughout; cilia grey, on dorsum ochreous-tinged. Hindwings lanceolate; pale-grey; cilia 4, ochreous-tinged.

Queensland: Roma in September; six specimens.

Phaneroctena homopsara, n.sp.

♂ ♀ 10-13 mm. Head and thorax brownish-grey. Palpi, antennae, abdomen, and legs grey. Forewings narrow, apex pointed; brownish-grey; cilia brownish-grey. Hindwings lanceolate; grey; cilia 4, grey.

Queensland: Brisbane in April; Dalby in April; three specimens.

Phaneroctena pentasticta, n.sp.

♂ 10 mm. Head, palpi, antennae, and thorax pale-grey. [Abdomen broken off.] Legs grey. Forewings moderate, apex pointed; pale-grey; five obscure grey dots, first on fold at ¼, second in middle of disc at ⅓, third on fold at ½, fourth above tornus, fifth in middle of disc at ¾; cilia pale-grey. Hindwings lanceolate; grey; cilia 4, grey.

Queensland: Brisbane in March; one specimen.

Scythris fumida, n.sp.

♂ ♀ 10 mm. Head, thorax, palpi, and antennae fuscous. Abdomen grey. Legs fuscous; hairs on dorsum of posterior tibiae grey-whitish. Forewings narrow, apex pointed; fuscous with some pale-fuscous irroration; cilia fuscous. Hindwings lanceolate; grey; cilia 5, grey.

Queensland: Charleville in September; four specimens.

Fam. HELIODINIDAE.

Isorrhoa pandani, n.sp.

♂ ♀ 11-14 mm. Head grey; face whitish. Palpi whitish with some grey irroration. Antennae whitish annulated with fuscous. Thorax grey. Abdomen grey-whitish; dorsum suffused with ochreous. Legs whitish annulated with greyish-fuscous. Forewings narrow, apex acute, termen very oblique; grey finely strigulated with fuscous; three inwardly oblique fuscous transverse lines, their anterior margins whitish, first from ¼ costa to ¼ dorsum, second from midcosta to middorsum, third from ¾ costa to tornus, interrupted in middle; apical

area with some fuscous irroration; cilia pale-grey with a darker dot at apex, bases fuscous irrorated with whitish. Hindwings narrowly lanceolate; pale-grey; cilia pale-prey.

Northern Territory: Darwin; six specimens bred from larvae on *Pandanus odoratissimus*, by Mr G. F. Hill. The larvae construct neat oval cases of two segments cut out of the leaves, consisting each of the whole thickness of the leaf, and leaving oval perforations after their removal.

ISORRHOA LOXOSCHEMA, n.sp.

♂ ♀ 15 mm. Head pale-ochreous; face and palpi white. Antennae pale-ochreous; basal joint white. Thorax pale-ochreous; patagia white. Abdomen ochreous; beneath whitish. Legs whitish; anterior tibiae and tarsi pale-fuscous, middle and posterior broadly ringed with pale-fuscous. Forewings rather narrow, apex pointed; pale-ochreous marked with white; a basal suffusion; a transverse line at ⅓; connected by costal and median streaks with an inwardly oblique line from ⅔ costa to mid-dorsum; an oblique line beyond this sometimes indistinct; an apical dot; a few fuscous scales in apical part of disc; cilia pale-ochreous, on apical dot with blackish bases, on dorsum grey. Hindwings lanceolate; grey; cilia 4, grey.

Queensland: Mount Tambourine in November; two specimens.

AEOLOSCELIS ANCISTROTA, n.sp.

♂ 14 mm. Head white. Palpi white; external surface of second joint pale-fuscous. Antennae white with pale-fuscous annulations; in ♂ serrate towards apex, without perceptible ciliations. Thorax white; bases of patagia and some anterior irroration fuscous. Abdomen orange-ochreous; beneath whitish. Legs whitish; anterior pair almost wholly fuscous; posterior tibiae, middle and posterior tarsi annulated with blackish. Forewings rather narrow, pointed; very short costal, median, and dorsal fuscous streaks from base; an outwardly curved transverse fuscous fascia at ⅙; four pale-ochreous spots before middle, consisting of a minute longitudinal streak beneath ⅓ costa, a larger and broader streak resting on fold, a third between fold and dorsum, and a sub-costal dot near middle; a very oblique fuscous fascia from ⅔ costa to mid-dorsum; a large circular fuscous tornal spot, connected with a similar subapical spot, and with costal end of second fascia; between this and fascia is an erect white triangle, its apex turned posteriorly to form a hook; between it and costa a small white spot; a white apical dot edged posteriorly with fuscous; cilia fuscous, on costa, beneath apex, and on dorsum ochreous-whitish. Hindwings lanceolate; grey; cilia 3½, ochreous-whitish.

Queensland: National Park (2,500 ft.) in December; one specimen.

AEOLOSCELIS THIOSTOLA, n.sp.

♂ 18 mm. Head pale-yellow. Palpi pale-grey; internal surface whitish-ochreous. Antennae fuscous; ciliations in ♂ ¼. Thorax fuscous. Abdomen grey; apices of segments and underside paler,

ochreous-tinged. Legs grey; anterior pair fuscous; posterior tibiae whitish-ochreous. Forewings broadly lanceolate, apex acute; pale yellow; a basal costal streak continued on costal edge to middle; an inwardly oblique fascia from midcosta to mid-dorsum, broadening towards dorsum, indented posteriorly beneath costa; a narrow fuscous suffusion on termen; cilia grey. Hindwings lanceolate; grey; cilia 3, grey.

Queensland: Charleville in September; one specimen.

CALICOTIS TRIPLOESTA, n.sp.

♂ 11 mm. Head and thorax white. Palpi white; a fuscous longitudinal line on outer surface of terminal joint. Antennae pale-grey; basal joint white; in ♂ minutely biserrate. Abdomen whitish with lateral fuscous dots. Legs whitish; posterior tarsi with dense whorls of pale-fuscous hairs. Forewings narrow, pointed; white; three transverse fasciae and an apical dot fuscous; first fascia at ⅙, broad, interrupted beneath costa; second slightly before middle, dilated on dorsum, rather suffused; third beyond ¾, broad, to termen; cilia whitish, on apex fuscous. Hindwings almost linear; pale-grey; cilia 8, whitish.

Queensland: Brisbane in September; one specimen.

STATHMOPODA PLATYNIPHA, n.sp.

♂ 12 mm. Head and palpi grey-whitish. Antennae whitish annulated with grey; ciliations in ♂ 3½. Thorax white. Abdomen grey; beneath white. Legs whitish. Forewings lanceolate, acute; white; three transverse fuscous fascia; first basal; second median, rather broad; third subapical, narrow, leaving extreme apex white; cilia grey, around apex white. Hindwings lanceolate; grey; cilia 5, grey.

North Queensland: Townsville in June; one specimen.

STATHMOPODA ACROMOLIBDA, n.sp.

♀ 10 mm. Head and thorax pale-yellow; face leaden-metallic. Palpi whitish. Antennae fuscous. Abdomen fuscous. Legs whitish; anterior tibiae and tarsi, and posterior pair, fuscous. Forewings narrowly lanceolate, acute; pale-yellow; a fine leaden-metallic subcostal streak to middle; a similar but broader costal streak from ⅔ to apex, pointed at each end; a transverse, fuscous, sub-basal mark from dorsum to fold; longitudinally elongate, fuscous, dorsal spots on mid-dorsum and tornus; cilia grey. Hindwings lanceolate; grey; cilia 5, grey.

Queensland: Brisbane in October; one specimen.

STATHMOPODA APHANOSEMA, n.sp.

♂ 10 mm. Head silvery-white. Palpi whitish. Antennae grey, towards base whitish; ciliations in ♂ 4. Thorax pale-yellowish. Abdomen grey; tuft and underside whitish. Legs whitish; anterior

pair grey. Forewings lanceolate; whitish; basal half suffused with pale-yellowish; cilia whitish. Hindwings narrow-lanceolate; grey; cilia 6, grey.

Queensland: Stanthorpe in October; one specimen.

STATHMOPODA PAMPOLIA, n.sp.

♂ 11 mm. Head, palpi, and thorax pale-ochreous-grey. Antennae grey; ciliations in ♂ 8. Abdomen grey. Legs ochreous-whitish; posterior pair grey. Forewings lanceolate; pale-ochreous-grey; cilia grey. Hindwings very narrowly lanceolate; grey; cilia 10, grey.

Queensland: Coolangatta in April; one specimen.

STATHMOPODA CERAMOPTILA, n.sp.

♀ 12 mm. Head and thorax reddish-brown; face shining grey-whitish. Palpi fuscous externally, whitish internally. Antennae grey. [Abdomen broken off.] Legs; anterior pair fuscous; middle pair whitish; posterior pair brownish-fuscous with whitish tarsal rings. Forewings lanceolate; reddish-brown; cilia grey, on apex reddish-brown. Hindwings narrow-lanceolate; grey; cilia 6, grey.

North Queensland: Kuranda near Cairns; one specimen received from Mr. F. P. Dodd.

PACHYRHABDA ANTINOMA, Meyr.

Stathmopoda cryerodes Turn. must be referred to the genus *Pachyrhabda*, and I strongly suspect it to be a synonym of this widely-distributed species. I lay stress especially on the apical blackish dots on the posterior tibiae.

Queensland: National Park (3,000 ft.). New South Wales: Ebor. Also from Kermadec Islands, Ceylon, and India.

PACHYRHABDA HYGROPHAES, n.sp.

♂ ♀ 9-10 mm. Head and thorax pale-yellowish; face and palpi whitish. Antennae pale-yellowish, towards apex grey. Abdomen grey. Legs whitish; posterior tibiae and tarsi ringed with fuscous. Forewings narrow, apex rather obtusely pointed; pale-yellowish; two fuscous-brown transverse fasciae; first at middle, rather broad, second narrower and darker at $\frac{3}{4}$; cilia pale-yellowish, on dorsum grey. Hindwings narrow-lanceolate; grey; cilia 7, grey.

Queensland: Gympie in April; Brisbane in September; three specimens.

PACHYRHABDA ADELA, n.sp.

♂ ♀ 10-11 mm. Head, palpi, antennae, and thorax ochreous-whitish. Abdomen fuscous, paler towards base; beneath whitish. Legs whitish; hairs on posterior tibiae fuscous. Forewings lanceolate, acute; whitish-ochreous; three suffused fuscous fasciae, first basal, second median, third broader and apical; in some ex-

amples the fasciae are broader and partly united by fuscous suffusion; cilia fuscous, on dorsum grey. Hindwings narrow-lanceolate; grey; cilia 6, grey.

Readily distinguished from the preceding by the basal fascia. It is a much duller insect, the fasciae have no brown tinge, and the last fascia extends to apex.

Queensland: National Park (2,500 to 3,000 feet) in December and January; three specimens.

PACHYRHABDA CAPNOSCIA, n.sp.

♀ 8 mm. Head, palpi, antennae, and thorax white. Abdomen whitish, with an apical dorsal fuscous spot. Legs whitish; apices of posterior tibiae and tarsal joints ringed with fuscous. Forewings rather broadly lanceolate, acute; white; three fuscous fasciae, first about middle, outwardly oblique, closely followed by second at ¾, and third apical; the fasciae are partly united by fuscous suffusion and tend to confluence; cilia fuscous. Hindwings narrow-lanceolate, grey; cilia 5, grey.

Queensland National Park (3,000 ft.) in February; one specimen.

PACHYRHABDA XANTHOSCIA, n.sp.

♀ 9 mm. Head, palpi, and antennae white. Thorax ochreous-whitish with a brown dot on each patagium. Abdomen whitish. Legs whitish; posterior tibiae and tarsi ringed with fuscous. Forewings narrow, pointed; ochreous-whitish; costal edge towards base and a sub-basal mark on dorsum yellow-brown; an inwardly-oblique, suffused, yellow-brown fascia from ⅓ costa to ¼ dorsum; wing beyond this suffused with very pale ochreous-grey; cilia grey. Hindwings narrow-lanceolate; grey; cilia 8, grey.

North Queensland: Kuranda near Cairns in June; one specimen.

ACTINOSCELIS ASTRICTA, n.sp.

♀ 9 mm. Head shining grey. Palpi, antennae, thorax, abdomen, and legs grey. Forewings narrow-lanceolate; grey; cilia grey. Hindwings linear; grey; cilia 16, grey.

Much narrower-winged than any other Australian genus. I am unable to make out the neuration of my solitary example, but it corresponds very nearly in structure to the unique ♂ type of Meyrick's genus *Actinoscelis* from India: The labial palpi are drooping and very short, about equal to width of eye. Antennae are ¾, basal joint long and stout. The posterior tibiae are clothed with long coarse bristles on basal ¾ of dorsum, smooth between spurs; on apices of tibiae and three first tarsal joints are whorls of long bristles; the apex of basal inner spur terminates in a whorl of fine bristles.

Quensland: Caloundra in August; one specimen.

Gen. **Lissocarena**, nov.

Head smooth, forehead forming a broad rounded fillet, crown depressed, face retreating. Antennae nearly 1 basal, joint moderate; in

♂ simple, without ciliations. Labial palpi long, recurved, diverging, smooth-scaled; terminal joint as long as second, rather broadly dilated but laterally compressed, obtusely pointed. Maxillary palpi minute. Posterior tibiae and first tarsal joints clothed with short stiff hairs on dorsum; minute whorls of short hairs on apices of three first tarsal joints. Forewings with 7 and 8 stalked, 7 to costa, 11 from beyond ¾. Hindwings with 4 absent, 6 and 7 separate at origin, not approximated.

LISSOCARENA SEMICUPREA, n.sp.

♂ ♀ 10-12 mm. Head grey; face silvery-whitish. Palpi whitish or whitish-grey. Antennae grey or fuscous. Thorax grey. Abdomen grey or fuscous, paler beneath. Legs whitish; posterior pair grey or fuscous on dorsum. Forewings moderate, apex rounded; grey; costal edge sometimes ochreous; sometimes a white line or narrow fascia from ¾ costa to tornus, but this may be partly or wholly obsolete; cilia grey. Hindwings under 1, lanceolate; coppery-orange; extreme apex sometimes grey; cilia 1½, grey, sometimes coppery-tinged.

North Queensland: Kuranda near Cairns in September and October; four specimens received from Mr. F. P. Dodd.

SNELLENIA MILTOCROSSA, n.sp.

♀ 20 mm. Head blackish; face tinged with red. Palpi and antennae blackish. Thorax blackish; bases of patagia reddish. Abdomen blackish. Legs blackish; posterior tarsi with three white rings. Forewings rather narrow, posteriorly dilated, costa straight, apex and termen evenly rounded; blackish with a slight reddish suffusion on posterior veins and termen; a reddish costal streak throughout; cilia reddish, bases blackish. Hindwings ovate-lanceolate; fuscous; cilia ⅔, fuscous.

New South Wales: Stanwell Park near Bulli in March; one specimen received from Mr. G. N. Goldfinch.

END OF VOLUME XXXVI., PART 1.

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[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. II., 1924].

ART. VII.—*Further Studies in Contagious Bovine Pleuro-pneumonia Experiments to demonstrate the occurrence of two distinct types of the virus in Victoria.*

By G. G. HESLOP, D.S.O., D.V.Sc., D.V.H.

(Veterinary Research Institute, University of Melbourne.)

(Communicated by Professor H. A. Woodruff.)

[Read 9th August, 1923.]

The agglutination reaction for the diagnosis of contagious pleuro-pneumonia of bovines has been employed extensively in Victoria during the past two years with very satisfactory results. The technique employed has been fully described in a previous article (1) published by the present author.

During 1922 a number of blood samples were received for test purposes from a farm near Melbourne, on which an outbreak of disease had occurred in a herd of dairy cows, which disease was suspected to be contagious pleuro-pneumonia. The sick animals supplying the blood samples showed very high temperatures—up to 106.2° F., and also showed such clinical signs of contagious pleuro-pneumonia as coughing, rapid emaciation, and areas of dullness in the lungs.

When blood samples from these sick cows were submitted to the agglutination test (using a stock culture—referred to subsequently as "Culture Y"—as antigen) a negative reaction was obtained in each case, but on submitting the animals supplying the test sera to post-mortem examination, it was found that they, without exception, were affected with contagious pleuro-pneumonia in a very active and acute form.

From one of these sick animals a culture of the organism of contagious pleuro-pneumonia was obtained (this culture is referred to subsequently as "culture X")—which, after sub-culture in Martin's broth ox serum media for 10 generations, was agglutinated by the sera in high dilutions from sick animals from the same farm. The same sera from the same sick animals, however, had little or no agglutinating effect, even in the lowest dilutions, upon "culture Y," which was obtained from another farm many miles distant, and which had been used almost exclusively as antigen in previous agglutination tests with entirely satisfactory results.

The two cultures—"culture Y" and "culture X"—were alike in appearance and in their cultural characteristics in Martin's broth ox serum media. The fermentation reactions of both cultures were found to be identical; that is, they both gave the following reactions:—

	Saccharose	Glucose	Maltose	Lactose	Mannite	Dulcite
Acid	—	++	+	—	—	—
Gas	—	—	—	—	—	—

+ = acid; ++ = strongly acid; — = no reaction.

Both cultures, however, showed marked differences in their behaviour towards known positive sera when used as antigen for the tests of these sera. These differences can be summarised as follows:

"Culture X" plus several known positive sera gave some positive and some negative reactions.

"Culture Y" plus the same known positive sera gave positive reactions with those sera reacting negatively with "culture X," and gave negative reactions with those sera reacting positively with "culture X."

It is not proposed in this paper to enumerate all the initial experiments which have been conducted with "culture X" and "culture Y" and with known positive sera; suffice it to say that after numerous experiments and using over 30 different known positive sera, it became apparent that there were at least two distinct strains or types of the organism of contagious pleuro-pneumonia present in Victoria. These strains are only agglutinated in the higher dilutions by known positive sera of homologous type; that is to say, "culture X" is only agglutinated in high dilutions by sera from sick animals in which the causal organism is also type X, and "culture Y" is similarly only agglutinated in high dilutions by sera from sick animals in which the causal organism is type Y. Type X culture with a type Y serum invariably gives a negative reaction, as also does type Y culture with a type X serum. There is apparently no intermediate type between the two types of organism already referred to, as, in the experiments conducted, it has been found that no known positive serum has given a positive agglutination reaction to both "culture X" and "culture Y." Such a serum has always reacted positively to the one type, and negatively to the other. Typical examples of these reactions are set out in detail in Table I.

As it was apparent from the initial experiments conducted with "culture X" and "culture Y" that these cultures were only agglutinated in high dilutions by a positive serum of homologous type, it was decided to carry out a series of absorption experiments and note the behaviour of both cultures after absorption with homologous and non-homologous sera. These experiments are set out in detail in Table I. and Table II., and are summarised in Table III. Eight distinct series of agglutination tests—lettered A to H inclusive (see Table I.)—were first set up, and after incubation at 37° C. for 48 hours, the reaction which developed in each tube was carefully noted. The content of each tube was then centrifuged and 1 c.c. of the supernatent fluid from each tube in the series was then introduced into a correspondingly numbered tube in another series—lettered A(a) to H(h) inclusive; that is to say, 1 c.c. of fluid from

tube 1 in series A was put into tube 1 of series A(a), and so on. The reactions which developed after incubation for 48 hours at 37° C. are shown in Table II. already referred to.

It will be seen, on reference to these tables, that it is possible to mix "culture Y" and a positive serum (type X), and absorb all the non-specific[1] agglutinations, but at the same time the specific agglutinins for "culture X" are retained in the supernatent fluid unimpaired, and can be demonstrated by mixing 1 c.c. of that supernatent fluid with 1 c.c. of "culture X" in a subsequent test—see series B and B(b). A similar result can be obtained when a positive serum (type Y) is submitted to absorption by "culture X," and is then mixed with "culture Y"—see series E and E(e). When, however, a known positive serum is added to a culture, homologous in type with the particular serum used, a positive reaction is developed after incubation, and both the specific and the non-specific agglutinins are removed from the supernatent fluid, and this supernatent fluid, if again added to culture, whether homologous or non-homologous, gives a negative reaction even in the lowest dilutions—see series A and A(a).

TABLE I.

Tube.	Culture	Serum 1-10	Saline.	Dilution	Result.	Remarks.
	c.c	c.c	c.c			
1	1	1	—	1.20	+++	Serum No. 557 (type X)
2	1	.5	.5	1.40	+++	Culture Type X
3	1	.25	.75	1.80	+++	
4	1	.2	.8	1.100	++	Series A
5	1	.15	.85	1.133	+	
6	1	—	1	—	—	
7		1	1	—	—	
1	1	1	—	1.20	+	Serum No. 557 (type X)
2	1	.5	.5	1.40	S	Culture Type Y
3	1	.25	.75	1.80	—	Series B
4	1	.2	.8	1.100	—	
5	1	.15	.85	1.133	—	
6	1	—	1	—	—	
7		1	1	—	—	
1	1	1	—	1.20	+++	Serum No. 558 (type X)
2	1	.5	.5	1.40	+++	Culture (type X)
3	1	.25	.75	1.80	++	
4	1	.2	.8	1.100	++	Series C
5	1	.15	.85	1.133	++	
6	1	—	1	—	—	
7		1	1	—	—	

1.—The terms "specific" and "non-specific" are used throughout this paper in the restricted sense of relation to the type of the organism or serum. For example, "culture X" is specific to the serum of an animal affected with type X organism, but is non-specific to the serum of an animal affected with type Y organism

TABLE I. (Continued)

Tube.	Culture.	Serum 1-10	Saline.	Dilution.	Results.	Remarks.
1	1	1	—	1.20	++	Serum No. 558 (type X)
2	1	.5	.5	1.40	+	Culture (type Y)
3	1	.25	.75	1.80	S	
4	1	.2	.8	1.100	—	Series D
5	1	.15	.85	1.133	—	
6	1	—	1	—	—	
7	-	1	1	—	—	
1	1	1	—	1.20	++	Serum No. 428 (type Y)
2	1	.5	.5	1.40	+	Culture (type X)
3	1	.25	.75	1.80	S	Series E
4	1	.2	.8	1.100	—	
5	1	.15	85	1.133	—	
6	1	—	1	—	—	
7	-	1	1	—	—	
1	1	1	—	1.20	+++	Serum No. 428 (type Y)
2	1	.5	.5	1.40	+++	Culture (type Y)
3	1	.25	.75	1.80	+++	Series F
4	1	.2	.8	1.100	+++	
5	1	.15	.85	1.133	++	
6	1	—	1	—	—	
7	-	1	1	—	—	
1	1	1	—	1.20	S	Serum No. 429 (type Y)
2	1	.5	.5	1.40	V.S.	Culture (type X)
3	1	.25	.75	1.80	—	Series G
4	1	.2	.8	1.100	—	
5	1	.15	.85	1.133	—	
6	1	—	1	—	—	
7	-	1	1	—	—	
1	1	1	—	1.20	+++	Serum No. 429 (type Y)
2	1	.5	.5	1.40	+++	Culture (type Y)
3	1	.25	.75	1.80	++	Series H
4	1	.2	.8	1.100	++	
5	1	.15	.85	1.133	++	
6	1	—	1	—	—	
7	-	1	1	—	—	

+++ = Agglutination and sedimentation of agglutinated organisms with complete naked eye clearing of the supernatent fluid.

++ = Agglutination with well-defined deposit, fluid nearly clear.

\+ = Marked flocculent agglutination and some sedimentation, fluid not clear.

S = Slight agglutination deposit, fluid not clear.

— = No naked eye trace of agglutination or clearing of fluid.

TABLE II.

Tube.	Culture.	Fluid from Series A.	Saline.	Dilution.	Result	Remarks.
1	1 c.c.	1 c.c. tube 1	—	1.40	—	Serum No. 557 (Type X)
2	1 c.c.	1 c.c. tube 2	—	1.80	—	Culture (Type X)
3	1 c.c.	1 c.c. tube 3	—	1.160	—	
4	1 c.c.	1 c.c. tube 4	—	1.200	—	
5	1 c.c.	1 c.c. tube 5	—	1.266	—	Series A(a)
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	
		FLUID FROM B				
1	1 c.c.	1 c.c. tube 1	—	1.40	+ + +	Serum No. 557 (Type X)
2	1 c.c.	1 c.c. tube 2	—	1.80	+ + +	Culture (Type X)
3	1 c.c.	1 c.c. tube 3	—	1.160	+	
4	1 c.c.	1 c.c. tube 4	—	1.200	+	
5	1 c.c.	1 c.c. tube 5		1.266	+	Series B(b)
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	
		FLUID FROM C				
1	1 c.c.	1 c.c. tube 1	—	1.40	? V.S.	Serum No. 558 (Type X)
2	1 c.c.	1 c.c. tube 2	—	1.80	—	Culture (Type Y)
3	1 c.c.	1 c.c. tube 3	—	1.160	—	
4	1 c.c.	1 c.c. tube 4	—	1.200	—	
5	1 c.c.	1 c.c. tube 5	—	1.266	—	Series C(c)
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	
		FLUID FROM D				
1	1 c.c.	1 c.c. tube 1	—	1.40	—	Serum No. 558 (Type X)
2	1 c.c.	1 c.c. tube 2	—	1.80	—	Culture (Type Y)
3	1 c.c.	1 c.c. tube 3	—	1.160	—	Series D(d)
4	1 c.c.	1 c.c. tube 4	—	1.200	—	
5	1 c.c.	1 c.c. tube 5	—	1.266	—	
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	
		FLUID FROM E				
1	1 c.c.	1 c.c. tube 1	—	1.40	+ + +	Serum No. 428 (Type Y)
2	1 c.c.	1 c.c. tube 2	—	1.80	+ + +	Culture Type (Y)
3	1 c.c.	1 c.c. tube 3	—	1.160	+ +	
4	1 c.c.	1 c.c. tube 4	—	1.200	+ +	Series E(e)
5	1 c.c.	1 c.c. tube 5	—	1.266	+	
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	

TABLE II. (Continued)

Tube	Culture	Fluid from Series A.	Saline.	Dilution.	Result	Remarks.
		FLUID FROM F				
1	1 c.c.	1 c.c. tube 1	—	1.40	?V.S.	Serum No. 428 (Type Y)
2	1 c.c.	1 c.c. tube 2	—	1.80	—	Culture (Type X)
3	1 c.c.	1 c.c. tube 3	—	1.160	—	Series F(f)
4	1 c.c.	1 c.c. tube 4	—	1.200	—	
5	1 c.c.	1 c.c. tube 5	—	1.266	—	
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	
		FLUID FROM G				
1	1 c.c.	1 c.c. tube 1	—	1.40	+ + +	Serum No. 429 (Type Y)
2	1 c.c.	1 c.c. tube 2	—	1.80	+ +	Culture (Type Y)
3	1 c.c.	1 c.c. tube 3	—	1.160	+ +	
4	1 c.c.	1 c.c. tube 4	—	1.200	+	Series G(g)
5	1 c.c.	1 c.c. tube 5	—	1.266	S	
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	—	1 c.c. tube 7	1 c.c.	—	—	
		FLUID FROM H				
1	1 c.c.	1 c.c. tube 1	—	1.40	—	Serum No. 429 (Type Y)
2	1 c.c.	1 c.c. tube 2	—	1.80	—	Culture (Type X)
3	1 c.c.	1 c.c. tube 3	—	1.160	—	Series H(h)
4	1 c.c.	1 c.c. tube 4	—	1.200	—	
5	1 c.c.	1 c.c. tube 5	—	1.266	—	
6	1 c.c.	1 c.c. tube 6	—	—	—	
7	1 c.c.	1 c.c. tube 7	1 c.c.	—	—	

TABLE III.

(Summary of Tables I. and II.).

Series	Mixture	Result
Series A	Type X culture + Type X serum	= Positive reaction in all dilutions tested.
Series A(a)	Fluid from Series A + Type X culture	= Negative reaction, all agglutinins absorbed by the reaction developed in Series A
Series B	Type Y culture + Type X serum	= Negative reaction— only non-specific. Agglutinins give slight reaction in the two lowest dilutions.
Series B(b)	Fluid from Series B + Type X culture	= Positive reaction. Specific agglutinins not removed by the absorption experiment in Series B
Series C	Type X culture + Type X serum	= Positive reaction.
Series C(c)	Fluid from Series C + Type Y culture	= Negative reaction. Both specific and non-specific agglutinins absorbed by the experiment in series C
Series D	Type Y culture + Type X Serum	= Negative reaction. Only non-specific agglutinins reacting in lowest dilutions.
Series D(d)	Fluid from Series D + Type Y culture	= Negative reaction. All agglutinins to Type Y culture absorbed by experiment in series D
Series E	Type X culture + Type Y serum	= Negative reaction
Series E(e)	Fluid from Series E + Type Y culture	= Positive reaction. Specific agglutinins not absorbed by experiment in Series E
Series F	Type Y culture + Type Y serum	= Positive reaction.
Series F(f)	Fluid from Series F + Type X culture	= Negative reaction. Both specific and non-specific agglutinins absorbed by experiment in Series F
Series G	Type X culture + Type Y serum	= Negative reaction.
Series G(g)	Fluid from Series G + Type Y culture	= Positive reaction
Series H	Type Y culture + Type Y serum	= Positive reaction
Series H(h)	Fluid from Series H + Type X culture	= Negative reaction. Both specific and non-specific agglutinins absorbed by experiment in Series H

Reviewing the foregoing experiments, it is apparent that there are at least two distinct strains or types of the organism of contagious pleuro-pneumonia responsible for outbreaks of the diseases in Victoria. These two types are identical in their cultural characteristics and fermentation reactions, but differ in the manner of their behaviour when mixed with sera from animals affected with contagious pleuro-pneumonia.

The majority of outbreaks of contagious pleuro-pneumonia in Victoria appear to be produced by the type Y organism, but owing to the possibility of the other type being the causal organism in any outbreak, it has been found necessary, when conducting agglutination tests with suspected sera, to first ascertain the type of the organism responsible for the particular outbreak under investigation. Whenever possible, a known positive serum has been obtained from each outbreak to serve as a control. This known positive serum is tested with type X culture and type Y culture separately, and the extent of the reaction which is developed with each type of culture is carefully noted. In that way the type of the organism responsible for the outbreak is ascertained and sera from all suspected animals in the same herd can then be tested with a culture of the organism of the same type as that which is causing the disease in the herd.

Whenever a known positive serum is unobtainable from the outbreak in which the suspected animals are, it becomes necessary to test each suspected serum twice—firstly, against type X, and, secondly, against type Y, each separately—before it can be definitely stated that the animal supplying the sample is affected with or is free from the disease. A culture emulsion containing equal parts of types X and Y combined did not give satisfactory results, excepting in very acute cases of the disease, and was found to be very unreliable when the serum sample being tested was from an animal in which the disease was chronic.

(The agglutination reaction in contagious pleuro-pneumonia is always more marked and definite with the serum from an animal in which the disease is acute than that from an animal in which the disease is chronic.)

Prophylactic Inoculation.

Having established the fact that there are at least two distinct types of the organism of contagious pleuro-pneumonia present in Victoria, the question of prophylactic inoculation in the tail with culture or virus may have to be considered in the light of this knowledge. For instance, a prophylactic inoculation with culture or virus containing only type X organism may protect against type X organism, but not against type Y, and *vice versa*. It is worthy of mention that before the use of pure culture of the organism of contagious pleuro-pneumonia for prophylactic inoculation became so general in Victoria, experienced stock-owners have noted and commented upon the fact that the immunity obtained from tail inoculation appeared to be greatest when a sick animal was killed on the

farm, the virus collected from it, and used to inoculate all the contact animals of the herd. If "foreign" virus—that is, virus obtained on another farm, usually in another district—was used, they noted that very often there was very little, if any, immunity set up in the animals in which the "foreign" virus was inoculated. This observation, based as it was on empiric grounds, may have some foundation in the fact that when virus obtainable on the farm was used for prophylactic inoculation of the contact animals on the same farm, the type of organism present in the virus inoculated would be of the same type as that causing the disease on the farm, whereas when a "foreign" virus was used, the organism might or might not have been homologous in type with that causing the disease on the farm.

Experiments are now being conducted at the Veterinary Research Institute, Melbourne University, to ascertain whether the organism of one type will protect only against its own type, or will protect against both types.

LITERATURE.

(1) Heslop (1922): "Further researches into the serological diagnosis of contagious pleuro-pneumonia of cattle."—*Journal Comparative Pathology and Therapeutics*, vol. xxxv., part 1, March 1922, pp. 1-12.

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ART. VIII.—*Victorian Graptolites (New Series), Part I.*

By WM. J. HARRIS, B.A.

(Plates VII. and VIII.)

[Read 8th November, 1923.]

The first descriptions and figures of Victorian graptolites date back to 1874, when Sir F. McCoy[1] included several species, both Upper and Lower Ordovician, in his Prodromus of the Palæontology of Victoria. In the same year, R. Etheridge, Junr.[2] also published a paper with some good figures. Then, after many years, Mr. (afterwards Dr. G. B. Pritchard[3] dealt with some Lancefieldian forms, and Dr. T. S. Hall began the work which he was to pursue for over twenty years, and which entitled him to rank as one of the foremost authorities on Australian graptolites. Apart from incidental descriptions when dealing with collections—many such descriptions being included in the publications of the Geological Surveys of Victoria and New South Wales—Dr. Hall published a series of papers on Victorian graptolites. In Part I.[4], Dr. Hall dealt with Upper Ordovician graptolites of Matlock, and a new species of Dictyonema; Part II.[5], 1898, is concerned with the Lancefieldian series; Part III.[6], 1905, describes the Mount Wellington (Upper Ordovician) graptolites, while Part IV.[7], 1914, describes and figures some new or little-known species. Other descriptions, on a smaller scale, the work of R. A. Keble, have been published by the Geological Survey of Victoria. Mr. Keble, in collaboration with the writer, also figured some new Lower Ordovician forms in a paper read before this Society.[8]

The adoption of Dr. Hall's serial name for this article may appear unauthorised, but any other title would probably duplicate, or closely approximate to, the titles of some of Dr. Hall's numerous papers on the subject. The beginning of a new series should prevent confusion.

The first section of the present paper deals with some Lower Ordovician forms from the Castlemaine district, mentioned in an earlier article and there figured[9] but not described. With them is

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1.—McCoy, F., Prod. Pal., Vict., 1874, Dec. 1, et seq
2.—Etheridge, R., Junr., Ann. Mag. Nat. Hist., 1874, sec. 4, vol. 14.
3.—Pritchard, G. B., Proc. Roy. Soc. Vict. (n.s.), 1894, vol. vi.; 1895, vol. vii.
4.—Hall, T. S., Proc. Roy. Soc. Vict. (n.s.), 1897, vol. x.
5.—Ibid., 1899, vol. xi., part 2.
6.—Ibid., 1905, vol. xviii., part 1.
7.—Ibid., 1914, vol. xxvii., part ?
8.—Harris, W. J., and Keble, R. A., Proc. Roy. Soc. Vict., 1916, vol. xxix. (n.s.), part 1, pl. 1.

here included an important zonal graptolite mentioned in the same article but not further treated there. This portion of the paper represents some of the material intended for the second part of the work on the Castlemaine Rocks—a work suspended by the author's removal from the district. Section A therefore contains descriptions of:

Didymograptus v-deflexus, sp. nov.
Cardiograptus, Harris and Keble.
Cardiograptus morsus, H. and K.
Oncograptus biangulatus, H. and K.
Diplograptus gnomonicus, H. and K.

It also includes a note on *Trigonograptus ensiformis*, and description and figures of *Lasiograptus etheridgei*, sp. nov., previously figured by Etheridge[2] as *Diplograptus mucronatus*.

The second section of the paper deals with some Upper Ordovician graptolites from an outcrop at the junction of Riddell's and Jackson's Creeks in the Gisborne district. Descriptions and figures are given of:

Retiograptus speciosus, sp. nov.
Climacograptus riddellensis, sp. nov.
(previously recorded by McCoy[1] as *Diplograptus rectangularis.*)
Glossograptus hincksii, Hopkinson sp.
(previously recorded by McCoy[1] as *D. mucronatus.*)
Didymograptus caduceus, Salter.
Cryptograptus tricornis, Carruthers.

while a note on *Thamnograptus capillaris* is also appended.

I am endebted to Mr. F. Chapman, A.L.S. of the National Museum, Melbourne, for valuable advice during the preparation of this paper."

DIDYMOGRAPTUS V-DEFLEXUS, nov. sp.

(Plate VII., figs., 1, 2.)

(Nomen nudum, Harris, W. J.. Proc. Roy. Socy. Vict., 1916, Vol. XXIX., n.s., p. 11.,p. 55., 60 et. seq.)

Description.—Sicula fairly broad, about 1.1mm. in length. Stipes deflexed, originating sub-orally at an angle of 120°. The angle between the stipes soon diminishes to 90-95°, but then increases until ultimately it becomes 150° or more, in lengthy specimens, 180°. The changes in the angles between the stipes gives the specimens their characteristic outline. Thecae, 9 to 11 in 10mm., inclined at 30°, three or four times as long as wide, ventral margins of proximal thecae concave, but of distal thecae straight Apertural margins slightly concave and inclined at an angle of 110° to the axis of the stipe. The thecae overlap each other by about one half. The closer arrangement of the thecae is perhaps the

more common. Width over first theca, about .7mm., increasing gradually to slightly more than 1mm., and then remaining constant.

Remarks.—In so much as this graptolite belongs to the small group of deflexed Didymograpti, it resembles, in external form, *D. v-fractus*, Salter, and *D. deflexus*, E. and W. Its resemblance to these forms is only superficial, and probably the most closely related form is *D. uniformis*, E. and W., which precedes it in the Castlemaine beds and is found with it in the Darriwil series. From *D. uniformis*, it may be distinguished by the greater initial angle of divergence of the stipes and by their later convergence and ultimate separation. In other words, *D uniformis* belongs not to the deflexed, but to the horizontal series. Occasionally forms of *D. v-deflexus* are found in which the characteristic curves are so poorly shown that confusion may be possible between them and specimens of *D. uniformis*.

The following table shows the characteristics of the species mentioned:

	D deflexus	D v-fractus	D uniformis	D. v deflexus
Form	Deflexed	Deflexed	Horizontal with marked proximal curvature	Deflexed
Thecae in 10 mm.	14	8-10	11	9-11
Inclination	25-30°	35-55°	30°	30°
Divergence		90-40-130°	To 180°	120-90-150°
Overlap			½ to ⅔	½

Didymograptus v-deflexus is a characteristic fossil of the Darriwil series, being found at most outcrops of the series in the Castlemaine and Gisborne districts. Some of the more important localities are Chinaman's Creek (Note 6, QS. 14 SE), Woodbrook Road, Maldon Road, Yapeen, and Guildford in the Castlemaine area: along Upper Jackson's Creek, and North and South of Macedon railway station in the Gisborne district.

The type specimens are in the National Museum, Melbourne, and were collected by the Geological Survey of Victoria, at Ba 91, Guildford. The small excavation from which they were obtained is still visible though half a century has elapsed since it was made. I desire to thank the Museum authorities for permission to describe the specimens, which, on account of their origin, are of greater value than the numerous examples in my own collection.

CARDIOGRAPTUS, Harris and Keble.

The type of this genus is *Cardiograptus morsus*, figured by Harris and Keble.[9]

Description.—Rhabdosome lanceolate, the distal end deeply emarginate. Thecae long, of the type of *Didymograptus caduceus*, narrow, expanding, and slightly curved. In all respects except

9.—Harris, W. J., and Keble, R. A., Proc. Roy. Soc. Vict., 1916, vol. xxix. (n.s.), part 1, pl. 1, figs. 1-3.

shape the genus resembles *Oncograptus*, T. S. Hall, with which it is associated in the field.

Remarks.—Like *Oncograptus*, *Cardiograptus* appears to be a derivative from *Didymograptus caduceus*, Salter. It is easily distinguished from all other graptolites by its shape. It differs from *Oncograptus* in that

1. The whole rhabdosome is biserial. Examination of scores of specimens has failed to reveal one with uniserial stipes.
2. The outer margins of the rhabdosome are convex.

CARDIOGRAPTUS MORSUS, Harris and Keble.

1916, *Cardiograptus morsus*, Harris and Keble, Proc. Roy, Soc. Vict., Vol. XXIX., (n.s.), part 1, pl. 1, figs. 1-4.

Description.—Rhabdosome lanceolate, distal end deeply emarginate. Length from apex to base of emargination, 18-24 mm. The rhabdosome expands gradually to its maximum width, and then contracts slightly. Thecae 9-11 in 10mm. At the proximal end they are almost parallel to the axis, but soon turn through an angle of over 90° and towards the distal end have turned so much further that they make an angle of 320-340° with the axis. They are of the *Didymograptus caduceus* type, and are in contact for almost their whole length. The aperture is trumpet-shaped, with a long recurved denticle. The sicula is large—2mm. long and .5mm. broad.

Remarks.—The first theca seems to originate sub-orally, and the first thecae grow almost parallel with the sicula and project beyond its aperture. The thecae then turn through an angle as described above so that the sicula becomes embedded in the rhabdosome and is rarely, if ever, visible in mature specimens. Young forms bear a close resemblance to *D. caduceus, var. nanus*, Ruedemann var.[10], and it seems as if the tendency which, in America, produced this variety, in Australia was even more pronounced, giving rise to this new genus. In a previous paper[11] a note suggested the possibility of *C. morsus* being a four-branched form like *Phyllograptus*. It seems desirable now to cancel this suggestion, as further work has failed to confirm it. The establishment of new genera for *Oncograptus* and *Cardiograptus* is necessary under the present system of graptolite nomenclature, for though the line of descent of both forms through *D. caduceus* seems clear, confusion would be caused by grouping all as Didymograpti.

Horizon and Localities.—*Cardiograptus morsus* is an important zonal graptolite of the Middle Darriwil. It occurs with *Oncograptus*, but not in the lowest beds in which *Oncograptus* is found. It then survives *Oncograptus*, but is not found in the highest Darriwil

10.—Ruedemann, R., Grap., N.Y., 1904, part 1, p. 698, fig. 90.
11.—Harris, W. J., Proc. Roy. Soc. Vict., 1916, vol. xxix. (n.s.), part 1, p. 66, note.

zone. Its associates include *Oncograptus upsilon*, *O. bi-angulatus*, *Didymograptus caduceus*, *D. forcipiformis*, *Phyllograptus sp.*, *Trigonograptus ensiformis*, *Diplograptus*, *spp.*, and *Glossograptus*.

It is common at most Middle Darriwil localities, such as Chinaman's Creek (Note 6, QS. 15 NW.), Yapeen, Guildford, Macedon, Woodend, Ingliston, Gisborne, and Darriwil.

ONCOGRAPTUS BI-ANGULATUS, Harris and Keble.

1916, Harris and Keble, Proc. Roy. Soc. Vict., Vol. XXIX., (n.s.), part 1, pl. 1, figs. 7-9.

Description.—Uniserial portion about 8mm. long. Breadth at level of bifurcation 8mm., width of uniserial branch about 3mm., length of branch 2cms. or more, branches diverging at an angle of about 30°. Thecae about 10 in 10mm., at first growing downwards in the direction of the sicular aperture, and projecting beyond it. Successive thecae then gradually turn until they are inclined at 310-320° to axis of stipe, this angle then being maintained. Apertures trumpet-shaped, of the character of *Didymograptus caduceus*, with a long recurved denticle.

Remarks.—This species differs from *Oncograptus upsilon*, T. S. Hall, in being narrower and in having longer uniserial branches. Both *Oncograptus upsilon* and *O. bi-angulatus* resemble in shape blunted arrow heads, but while *O. upsilon* would form an arrow with external surfaces inclined at 50° to each other, the angle in the case of *O. bi-angulatus* is only about half this.

Horizon and Localities.—The writer has not found this form in association with *Oncograptus upsilon*. It is common with *Cardiograptus morsus* at Chinaman's Creek, Castlemaine (Note 6, QS 15 NW.), in middle Darriwil beds, and is also found in Allot. 9 of Sec. 7, east of the Guildford-Daylesford Road (QS 15 SE.).

DIPLOGRAPTUS GNOMONICUS, Harris and Keble.

1916, Harris and Keble, Proc. Roy. Soc. Vict., Vol. XXIX., (n.s.), part 1, pl. 1, figs. 5, 6.

Description.—Rhabdosome invariably minute, less than 10mm. in length and with a maximum breadth of 2mm., doubly convex, with indefinite margins owing to the tenuity of the test. Thecae closely arranged, at first growing in the direction of the sicular aperture and then gradually turning through an angle of more than 90°. Virgula long, and usually conspicuous.

Remarks.—It is difficult to draw up an adequate description owing to the extreme tenuity of the whole form. It is usually preserved as a thin film surrounding the well marked virgula and inter-thecal walls, which stand out as fine but firm lines in the central portions of the rhabdosome. The film then fades off into the surrounding shale without showing details of the apertural portions of the thecae.

The species is named from the gradual reversal of the direction of the thecae.

Horizon and Localities.—*Diplograptus gnomonicus* is typical of the middle and upper Darriwil beds, and is found with *Didymograptus v-deflexus*, *Trigonograptus ensiformis*, *Oncograptus*, *Cardiograptus morsus*, and *Didymograptus caduceus* at outcrops where the matrix is favorable for the detection of such a form as, for example, in both road and railway cuttings between Guildford and Strangways; at Chinaman's Creek; and at, or near, Ba 91, south of Guildford (QS 15 SE.).

TRIGONOGRAPTUS ENSIFORMIS, J. Hall, sp.

1865, *Retiolites ensiformis*, J. Hall, Geol. Surv. Can., dec. 2, p. 114, pl. 14, figs. 1-5.

1904, *Trigonograptus ensiformis*, Ruedemann, Grap. N.Y., pt. 1, p. 727, pl. 17, figs. 1-9.

1908 *Trigonograptus ensiformis*, Elles and Wood, Brit. Grap., pt. 7, p. 302, pl. XXXV., figs. 1, a-c.

(For further references vide Ruedemann, sup. cit.

Description.—Rhabdosome long, lanceolate, reaching its maximum width of 5mm. or more about 2cms. from the sicular end, and converging similarly at the distal end. Greatest length unknown. Margins usually perfectly linear and unbroken. Thecae indicated by the thick interthecal walls, slightly alternate, in contact throughout their whole length, 11 in 10mm. in the mature portions of the rhabdosome but more closely arranged near the sicula, forming an angle of 45° with the axis of the rhabdosome. In most specimens a straight stout virgula is visible even when other details of structure are absent.

Remarks.—Our specimens agree in all respects with those described from Great Britain[12] and America[13]. The thecae are rather more closely arranged than those of American specimens but agree with English measurements. Strange to say, this *Trigonograptus* is quite distinct from the only previously described Australian species, *T. wilkinsoni*, T. S. Hall[14], which has thecae inclined at 30°, 6½ in 10mm., oppositely aranged, and which is only 3mm. or less in width.

Localities and Horizon.—A typical graptolite of the Darriwil series, though, as yet, not recorded from Darriwil itself, where its place seems to be taken by *Trigonograptus wilkinsoni*. It is found at most other outcrops of the Darriwil beds, as, for example, Chinaman's Creek (Muckleford); near the N.W. boundary of the borough of Castlemaine; and at Guildford, Woodend, Macedon, and Gisborne.

12.—Elles and Wood, Brit. Grap., pt. 7, 1908, p. 302, pl. xxxv.

13.—Ruedemann, Grap., N.Y., pt. 1, 1904, p. 727, pl. xvii.

14.—Hall, T. S., Geol. Mag., 1899, dec. iv., vol. vi. (n.s.), p. 450-1, fig. 13.

LASIOGRAPTUS (THYSANOGRAPTUS) **etheridgei, sp. nov.**

(Plate VII., Figs. 3-7.)

1874, *Diplograptus mucronatus*, Etheridge, Junr., Ann. Mag. Nat. Hist., Sec. 4, Vol. 14, pl.3, figs. 16, 17.
1874, non *Diplograptus mucronatus*, McCoy, Prod. Pal. Vict., dec. 1, p. 10, pl. 1, figs. 5, 5a.

Description.—Rhabdosome about 2cms. in length and 4mm. in width (exclusive of the external meshwork), rapidly attaining its full width, which is then fairly well maintained though there is a slight narrowing towards the distal extremity. Thecae 9-11 in 10mm., apparently alternate, though this point is difficult to determine with certainty. Network delicate, yet impressed into the shale in such a way as to prove that the main threads, at any rate, were fairly substantial. The marginal network is usually well preserved, but is often missing from the distal portion of the rhabdosome, suggesting that is was not formed till a certain degree of maturity was reached by the thecae. Apertural margins of thecae apparently normal to the axis of the rhabdosome, virgular tube stout and often continued beyond the extremity of the rhabdosome.

Remarks.—After nearly half a century from the date of its first mention by Etheridge, an attempt is made to fix the identity of this distinctive graptolite. Etheridge[15] included it among the first Victorian graptolites described, identifying it with the *Graptolithus mucronatus*, of J. Hall This latter form has since been described by Elles and Wood[16] as *Lasiograptus* (*Hallograptus*) *mucronatus*, a graptolite which seems distinct from our Victorian species. *Lasiograptus mucronatus* is described as characteristically lax, and the figures (Pl. XXXIII) show that there is no well-devoloped meshwork in the English specimens. Ruedemann's figures also[17] show a *Lasiograptus mucronatus* distinct from ours. Referring to Etheridge's figures Dr. Ruedemann says[18]: "The form from the shales at Newham, near Lancefield, in Victoria, which has been identified by Etheridge with our species, is associated with species of the Deepkill zones or Point Levis shales, and represents a *Retiograptus*, closely related to *R. tentaculatus*, J. Hall. Neither can the Australian form identified by McCoy with this species have been properly placed." We do not agree with the identification with *Retiograptus*. McCoy's *D. mucronatus* in Victoria is a *Glossograptus* which we elsewhere identify with *Glossograptus hincksii*, and is from a higher horizon. Etheridge's *D. mucronatus*, figs. 16, 17, are of *Lasiograptus*. His figures 14, 15, from the Watchbox Ranges, Baynton, are Glossograpti.

15.—Etheridge, R., Junr., Ann. Mag. Nat. Hist., 1874, ser. 4, vol. 14, pl. 3, figs. 16, 17.
16.—Elles and Wood, Brit. Grap., 1908, part 7, p. 321.
17.—Ruedemann, Grap., N.Y., 1908, part 2, p. 480, figs. 456, 457; and pl. 29, 30, 31.

The specimen of *Lasiograptus etheridgei* figured in fig. 6 is from B 29 (QS 5 SW), Sec. 20, Newham, Etheridge's original locality and almost certainly from the same outcrop, which is of very limited extent. The present writer[19], in an earlier paper, referred to this locality, and to the confusion its apparently mixed fauna has caused. The only further comment necessary here is to state that Dr. Hall's opinion[20] that this Newham locality is an outcrop of the *Tetragraptus* zone has not been substantiated by further investigation, nor does there seem any strong ground for the more recent opinion that both Darriwil and Castlemaine horizons are represented[21]. *Diplograptus* and *Lasiograptus* are inconsistent with a position in the Bendigo series, and *Phyllograptus*, which was originally held to have become extinct in the middle Castlemainian, has been found to range well into the Darriwil series. The form which Dr. Hall discussed and compared with *Goniograptus thureaui*[22] is certainly not that species, and, while it may not be *Loganograptus logani*, it seems to be a related form.

Figures 3-5 are from a small roadside cutting between Secs. 95 and 98, south of Old Racecourse Hill, Woodend. These forms are more robust than those from Newham, and have only 9 thecae per 10mm., as against 10 or 11 in the Newham specimens. In other respects they agree.

Associates and Horizon. At B 29, Sec. 20, Newham, are found:

Didymograptus spp. (Mostly slender horizontal forms).
Didymograptus caduceus
Phyllograptus. sp.
Diplograptus, sp.
cf. Loganograptus logani
Climacograptus, sp.
Tetragraptus quadribrachiatus
Lasiograptus etheridgei

At the Woodend locality, *Phyllograptus* was not obtained, but we have the other forms mentioned, together with *Cryptograptus* and (?) *Cardiograptus morsus.*

Both beds are in the upper zones of the Darriwil series, possibly near the summit of the Lower Ordovician. Etheridge, as we have already seen, records the form from the Watchbox Ranges, Baynton.

Retiograptus speciosus, sp. nov.

(Plate VIII., Figs. 8-10.)

Description.—Rhabdosome small, usually less than 10mm. in length, and widening rapidly to a width of 3mm., which is then maintained or perhaps slightly exceeded. Test perhaps originally con-

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18.—Ruedemann, Op. Cit., p. 481.
19.—Harris, Proc. Roy. Soc. Vict., 1916, vol. xxix. (n.s.), part 1, p. 65.
20.—Hall, T. S., Proc. Roy. Soc. Vict., 1895, vol. vii. (n.s.), p. 73.
21.—Skeats and Summers, Bull. Geol. Surv. Vict., No. 24, 1912, p. 41.
22.—Hall, T. S., Prog. Rpt. IX., Geol. Surv. Vict., 1898, p. 126.

tinuous, but greatly attenuated so that in juvenile specimens and towards the distal end of mature specimens the lists which supported it are alone visible. Both sides, or rather the front and rear of the rhabdosome contain medial zigzag, ascending axes. Thecae, 14 in 10mm. Sicula not observed with certainty, and probably minute.

Remarks.—This form is quite unlike any other with which we are acquainted, though, when preserved so that the two ascending zigzags coincide, the outline agrees with that sometimes shown by *Retiograptus geinitzianus*, Hall. Its characteristic outline, however, is quite different, and so is the arrangement of parietal lists. These arise from the zigzag medial of each surface, at the apices of the zigzags. Their direction, especially near the proximal end of the rhabdosome, is at first almost horizontal, but they gradually ascend and form part of what may be called the ventral strands. The thecae appear to have been sub-rectangular in section in the body of the rhabdosome and the same shape is maintained throughout, though the axis of each theca is curved upwards, and the theca gradually narrows towards its aperture. The thecae seem to have been provided with a small mucro at each lower angle of the aperture. The test, as has been stated, is attenuated. In young specimens only the meshwork which supported it is preserved, while the typical specimens show the test covering all the rhabdosome except the distal portion, but so thinly that the lists show through it. Some specimens show a continuous test.

Localities and Horizon.—Common in the bluish shales at the junction of Riddell's and Jackson's Creeks, south of Riddell (Ba 67, QS 6 SE). As mentioned in an earlier paper, this locality is erroneously marked on the Quartersheets as Ba 68. The horizon is Upper Ordovician. From the presence of Didymograpti (including very rarely *Didymograptus caduceus*), and the absence of the Dicranograptidae, we conclude that these beds are among the lowest of the Upper Ordovician. This position is supported by the very common occurrence of *Glossograptus* and *Cryptograptus*, which both pass up from the Lower Ordovician.

Climacograptus riddellensis, sp. nov.

(Plate VIII., Figs. 11, 12.))

1874, *Diplograpsus, rectangularis*, McCoy, Prod. Pal. Vict., dec 1, pl. 1, fig. 7, 7a.

Description.—Rhabdosome in typical specimens about 3cms. in length, about .7mm. wide at proximal end, widening very gradually to an average breadth of 1.4 to 1.7 mm. This breadth is attained about 1 cm. from the sicula. The distal width may be slightly less. Virgella conspicuous but short (1 to 1.5mm.). The basal thecae are provided with small spines. Thecae 10-11, less rarely as many as 13 in 10mm., overlapping about one-third of their length, free outer edges straight and vertical, apertural margins horizontal. Excavations semi-

circular, occupying more than one-third of the width of the rhabdosome. Virgula often visible within the body of the rhabdosome, and prolonged beyond the distal end. The rhabdosomes with the more closely arranged thecae are usually slightly narrower than the typical form. The characters are remarkably constant in the great number of specimens examined.

Remarks.—*Climacograptus riddellensis* seems to be most closely allied to *C. antiquus*, Lapworth[23]. *C. antiquus*, is, however, broader, and the thecal indentations are shallower, relatively broader, and less curved. *C. antiquus* in England is commonest in the zone of *Nemagraptus gracilis*. In this zone, the Didymograptidae make their last appearance with *Didymograptus serratulus* and *D. superstes*, while the Leptograptidae and Dicranograptidae first appear. Glossograptus (including *G. hincksii*), *Diplograptus, Retiograptus* and *Lasiograptus* also occur. *Cryptograptus tricornis* is for the first time common[24].

The association at Jackson's Creek is what might be expected if *C. riddellensis* were to be regarded as the Australian representative of *C. antiquus*. We find *Retiograptus* (represented by the new *Retiog. speciosus*), *Cryptograptus tricornis* (very abundant), *Glossograptus hincksii, Diplograptus*, and some surviving Didymograptidae, including, very rarely, *Didymograptus caduceus*, the range of which in Victoria is not the same as has been worked out in England. One difference of association may be noticed: the Dicranograptidae and Leptograptidae are in Victoria seemingly representative of a higher horizon than in England and are not represented in the present collection. A careful comparison with figures of the type of McCoy's English *D. rectangularis*[25], shows that the two species are distinct. *D. (Climacograptus) rectangularis* is, moreover, a Silurian form[26].

McCoy's record[27] of *Diplograptus mucronatus* from Ba 67 is therefore erroneous if, as seems to be the case, this is the graptolite he was describing. (See particularly McCoy's fig 7a.)

GLOSSOGRAPTUS HINCKSII, Hopkinson, sp.

(Plate VIII., Figs. 13-16.)

1872, *Diplograptus hincksii*. Hopkinson, Geol. Mag., vol. IX., p. 507, pl. XII., fig. 9.

1874, *Diplograpsus mucronatus*. McCoy, Prod. Pal. Vict., dec. 1, p. 10, pl. 1, figs. 5, 5a.

1908, *Glossograptus hincksii*. Elles and Wood, Brit., Grap., pt. VII., p. 309, pl. XXXIII., figs. 2, a-j.

Description.—Rhabdosome rarely exceeding 3cms. in length, the usual length being about 2cms.; base rounded, widening rapidly to

23.—Elles, G. L., and Wood, E. M. R., Brit. Grapt., 1906, part v., p. 199, pl. xxvii., fig. 4 a-c.
24.—Ibid., 1914, part x., p. 521.
25.—Elles and Wood, op. cit., 1906, part v., p. 187, pl. xxvi., figs. 5 a-c.
26.—Ibid., 1914, part x., p. 519.
27.—McCoy, F., Prod. Pal. Vict., 1874, dec. 1, p. 11, pl. 1, figs. 7, 7a.

a maximum breadth of 2mm, which is then maintained. This applies to the bi-profile view—in the scalariform aspect the width is often slightly greater. Sicula obscure, apertural spines of sicula and of proximal thecae directed vertically downward. Virgular tube usually long and conspicuous. Thecae 11-12 in 10mm., overlapping rather less than half their length, apertural margins straight or but slightly everted, apertural spines strong, somewhat arcuate, nearly as long as width of rhabdosome, septal spines straight, spurlike, ascending.

Remarks.—The description above, drawn up from Jackson's Creek specimens, practically agrees with that given by Elles and Wood[28]. The English authors give the thecae as 16-10 in 10mm. Our specimens from the locality mentioned show greater constancy in spacing. In the scalariform view our forms also show a more spinous proximal portion than any of the English figured specimens, which leave this point rather obscure. The appearance shown by the specimens figured in figs. 14, 15 is characteristic.

McCoy[29] in 1874 figured this graptolite from the same locality as *Diplograptus mucronatus* — fig 5, natural size, being readily recognised as our species though the drawing is somewhat conventionalised. Dr. Ruedemann[30] has already pointed out that McCoy's and Etheridge's identifications were erroneous.

Horizon.—"Very abundant, and beautifully preserved in the white decomposed soft shale, Ba 67" (McCoy, p. 10). Ba 67 is at the junction of Riddell's and Jackson's Creeks, about three miles south-east of Riddell railway station on the Melbourne-Bendigo railway. The horizon is Upper Ordovician, but low in the series.

Didymograptus (isograptus) caduceus Salter.

(Plate VIII., 17 and 18.)

1853, *Didymograptus caduceus*, Salter (pars), Q.J. Geol. Soc., Vol. IX., p. 87, fig. 1a.
1874, *Tetragraptus bryonoides*, J. Hall (D. caduceus, Salter), Etheridge junr., Ann. Mag. Nat. Hist., ser. 4, pl. 3, figs. 3, 4.
1875, *Graptolites (Didymograpsus) caduceus*, McCoy, Prod. Pal. Vict., dec. 2, p. 30, pl. XX., figs. 3-5.
1901, *Didymograptus (Isograptus) gibberulus*, Elles and Wood, Brit. Grap., part 1, p. 52, pl. II., figs, 9, a-e.
1904, *Didymograptus (Isograptus) caduceus*, Ruedemann, Grap. N.Y., part 1, p. 693, pl. XV., figs. 6, 7.

Twenty-five years ago, Dr. T. S. Hall said[31], speaking of *D. caduceus*, "It is interesting to notice, as we pass up through a long series of rocks above those of Bendigo, that it increases

28.—Elles and Wood, 1908, supra.
29.—McCoy, 1874, supra.
30.—Ruedemann, 1908, Grap. N.Y., part 2, p. 481.

in relative numbers and at the same time gradually attains a much larger size till it reaches its maximum near the horizon of the uppermost Castlemaine beds, where it crowds the rocks to the almost entire exclusion of other forms. It then enters on the period of its decline, is but sparingly represented by stunted forms at Darriwil, and perhaps ranges up into the Upper Ordovician.." The writer is not aware of the evidence on which Dr Hall based this last presumption, although two facts may have influenced him. Firstly, *D. caduceus* is recorded from Guttamurrh Creek[32], a tributary of the Snowy River in eastern Gippsland, in an area regarded as Upper Ordovician, and, secondly, the occurrence, also in Gippsland, of a form somewhat like *D. caduceus* in external form and described by Dr. Hall later as *Didymograptus ovatus*[34]. We have been unable to gather any further information about the Guttamurrh Creek graptolites, while *D. ovatis* seems quite distinct from *D. caduceus*. However, it is now possible to figure *D. caduceus* from the Upper Ordovician of Ba 67, at the junction of Jackson's and Riddell's Creeks (QS 6 SE). Shale amounting to more than a ton had been searched before the first specimen came to light, so that it may be regarded as extremely rare on this horizon, which, from other considerations, we had already placed in the lower portion of the Upper Ordovician. The description of the specimen is given hereunder.

Description.—Stipes short, decreasing in width from the common point of origin where they are 2mm. wide over all, and forming a rhabdosome of a horse-shoe shape. Sicula long and slender. Thecae 6 in 10mm., curved, inclined to the axis at 30-40°, about four times as long as wide, in contact throughout their length. Apertural margins concave, angle obtuse.

Remarks.—It is remarkable that this description is almost identical with that given by Elles and Wood for the British lower Ordovician *D. caduceus* (gibberulus[33]), while it would be inaccurate for the species at the period of its maximum development at Castlemaine. Though *D. ovatus* has somewhat the same general appearance as some specimens of *D. caduceus*, its resemblance to the present specimen, even externally, is very slight, and when a detailed examination is made its distinctness is very evident, as will be shown by the following description of *D. ovatus*[34]: "Hydrosome stout, branches abruptly recurved and gradually approaching one another so that the polypary resembles in outline an imperfect specimen of *P. typus*. Thecae 12 in 10 mm., closely allied to *D. caduceus*, from which it differs in aperture of thecae and reflection of branches."

The specimens of *D caduceus* represented in figs. 17, 18 are now in the National Museum, Melbourne.

31.—Hall, T. S., Geol. mag. (n.s.), Dec. iv., vol. vi., 1899, p. 443.
32.—Prog. Report, Geol. Surv. Vict., No. 111, 1876, p. 186 (note).
33.—Elles and Wood, Brit. Grap., part 1, 1901, p. 52.
34.—Rec. Geol. Surv. Vict., 1902, vol. i., part 1, p. 33.

THAMNOGRAPTUS CAPILLARIS, Emmons, sp.

1885, *Nemagraptus capillaris*, Emmons, Amer. Geol. v. 1, pt. II., p. 109, pl. 1, fig. 6.

1893, non *Thamnograptus typus*, T. S. Hall, Austn. Assn. Adv. Sci.

1908, *Thamnograptus capillaris*, Reudemann, Grap. New York, part 2, p. 208, fig. 110 (copied from J. Hall, Pal. N.Y., 1859:3:519, fig. 22).

Description.—Only fragments of the rhabdosome have as yet been found. These consist of a straight or slightly zigzagged main stipe, from which secondary branches are given off on alternate sides, directed horizontally, at intervals of from 2 to 3mm. The main stipes that we have seen are less than 1mm. in width and the secondary branches are often hair lines. The longest fragment observed was apparently only the distal portion of a main stipe and was about 15cms. long. The material is too poorly preserved to enable any observations of thecae to be made, nor have we any evidence of the further branching of the secondary branches.

Remarks.—No drawings have been made as the material is too poorly preserved to show details of structure. The general appearance of the form may be gathered from J. Hall's original figure of *Thamnograptus typus*[35]. The Victorian form is not so coarse as the specimen there figured.

A certain amount of mystery has always surrounded the genus *Thamnograptus*, and this is not lessened by the occurrence in the Bendigo and Lower Castlemaine zones of forms externally resembling *Thamnograptus*. Dr. T. S. Hall[36], after referring them to *Thamnograptus*, finally, and with considerable hesitation, placed them in the genus *Goniograptus* as *G. crinitus*, and figured thecae observed on one of the finer branches. He remarked, however, that he had never found specimens with the typical *Goniograptus* aspect, i.e., with four main stipes. The writer has had the same experience and has, moreover, failed to find thecae on any specimens of *Goniograptus crinitus* which have come under his observation. The presence of thecae as figured by Dr. Hall is decisive enough to exclude *G. crinitus* from the genus *Thamnograptus*.

In 1919, the writer found fragments near Digger's Rest (Ba 62, QS 7 SE) and also at Gisborne. These fragments would have been referred to *Goniograptus crinitus* had their horizon been lower, but the Digger's Rest locality is Upper Ordovician, with Dicranograptidae, etc., while the Gisborne outcrop seems to represent one of the highest beds of the Lower Ordovician since *Tetragraptus*, *Diplograptus*, *Cryptograptus*, and *Trigonograptus* are found

It seems, therefore, preferable to record the present forms as *Thamnograptus capillaris*, and to leave the relationship with

35.—Ruedemann, R., Grap. N.Y., 1908, pt. 2, p. 208, fig. 110.
36.—Hall, T. S., Proc. Roy. Soc. Vict., 1914, vol. xxvii. (n.s.), pt. 1, p. 111.

Goniograptus crinitus (if any) for future investigation. The record of *Thamnograptus capillaris* is, therefore, strictly speaking, new for Victoria.

Localities.—Ba 62 (near Digger's Rest); Jackson's Creek, north of Gisborne township.

EXPLANATION OF PLATES.

PLATE VII.

Fig. 1.—*Didymograptus v-deflexus*, sp. nov. Holotype. East of Guildford-Daylesford Road, Ba 91, Allot. 9, sect. 7. Q.S. 15 S.E. Coll. Geol. Surv. Vict.

,, 2.—*Didymograptus v-deflexus*, sp. nov. Paratype. Same locality.

,, 3.—*Lasiograptus* (*Thysanograptus*) *etheridgei*, sp. nov. Holotype. Sects. 95, 98, Woodend. Coll. W. J. Harris; pres. Nat. Mus. Coll.

,, 4, 5.—*Lasiograptus* (*Thysanograptus*) *etheridgei*, sp. nov. Paratypes. Same locality. Coll. W. J. Harris; pres. Nat. Mus. Coll.

,, 6.—*Lasiograptus* (*Thysanograptus*) *etheridgei* sp. nov. Paratype. Newham. Ba 29, sect. 20. Coll. by W. J. Harris; pres. Nat. Mus. Coll.

,, 7. *Lasiograptus* (*Thysanograptus*) *etheridgei*, sp. nov. Paratype. Sect. 95. Woodend. Coll. W. J. Harris; pres. Nat. Mus. coll.

PLATE VIII.

,, 8.—*Retiograptus speciosus*, sp. nov. Holotype. Junction of Jackson and Riddell's Creeks. Ba 67. Coll. W. J. Harris; pres. Nat. Mus. coll.

,, 9.—*Retiograptus speciosus*, sp. nov. Paratype. Side view. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. × 1½.

,, 10.—*Retiograptus speciosus*, sp. nov. Paratype. Juvenile stage. Periderm almost absent. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. Nat. size.

,, 11.—*Climacograptus riddellensis*, sp nov. Holotype. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. (K1).

,, 12.—*Climacograptus riddellensis*, sp nov. Paratype. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. (K2).

,, 13.—*Glossograptus hincksii*, Hopkinson sp. Juvenile form. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. (Z1)

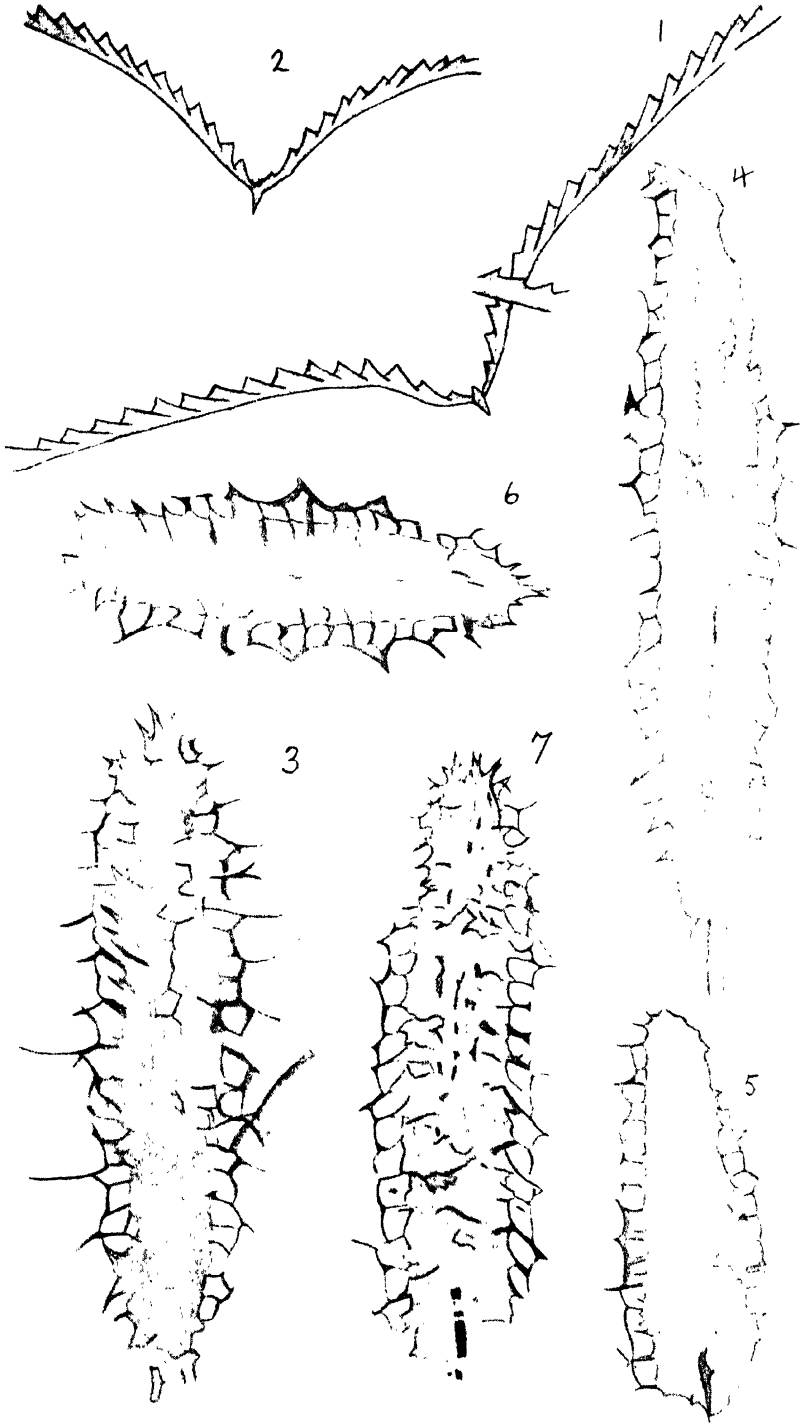
,, 14.—*Glossograptus hincksii*, Hopkinson sp. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. (Y1)

,, 15.—*Glossograptus hincksii*, Hopkinson sp. Specimen showing sicular and septal spines. Scalariform aspect. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. (Z2)

„ 16.—*Glossograptus hincksii*, Hopkinson sp. Sub-scalariform aspect. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll. (Z3)

„ 17.—*Didymograptus caduceus*, Salter. Upper Ordovician. Same locality. Coll. W. J. Harris; pres. Nat. Mus. coll.

„ 18.—*Didymograptus caduceus*, Salter. Another example. (D1). Coll. W. J. Harris; pres. Nat. Mus. coll.



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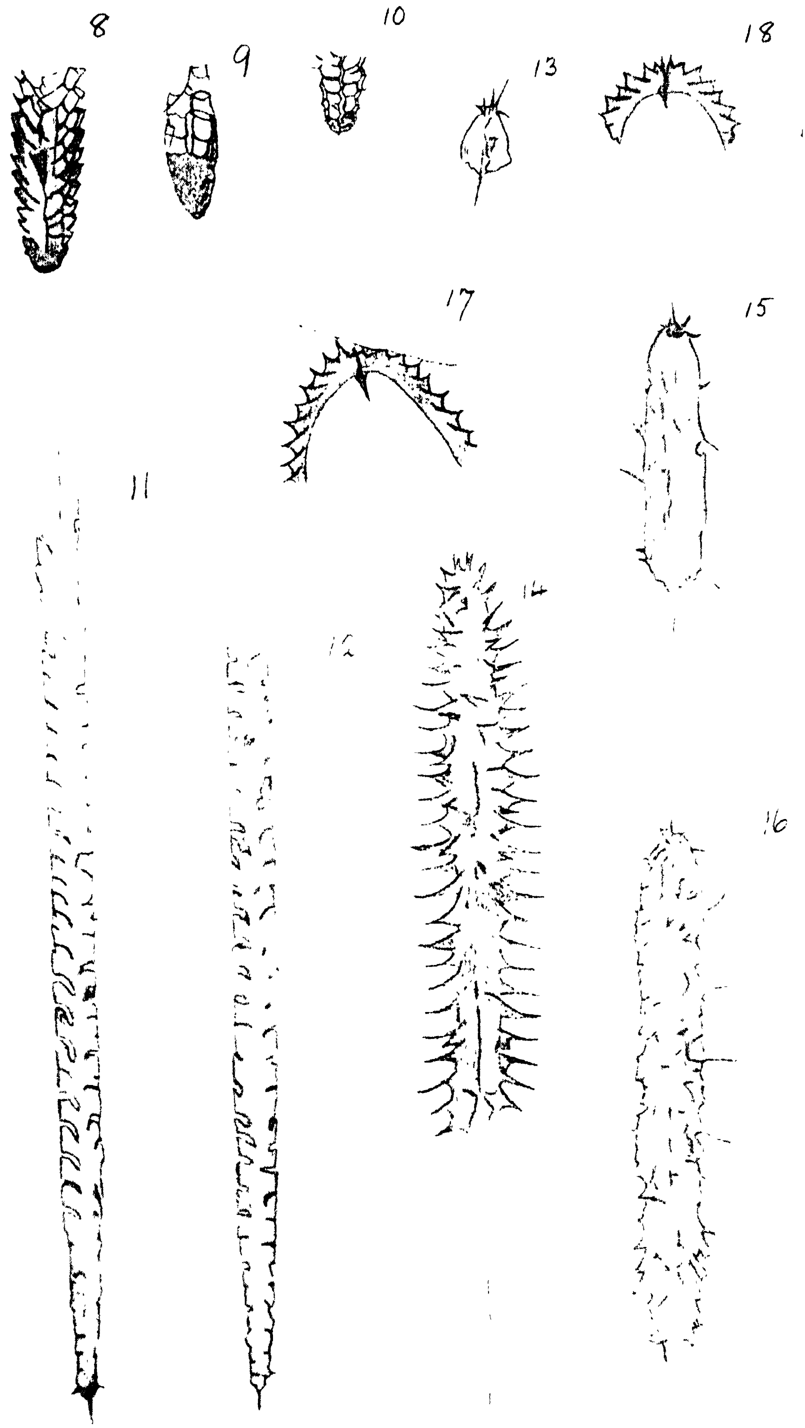
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[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. II., 1924.]

ART. IX.—*New or Little-known Fossils in the National Museum.*

PART XXVII.—SOME CAINOZOIC FISH REMAINS, WITH A REVISION OF THE GROUP.

BY FREDK. CHAPMAN, A.L.S., etc.
(Palaeontologist to the National Museum, Melbourne).

and

FRANCIS A. CUDMORE.

(With Plates IX.-XI.)

[Read 8th November, 1923.]

Introduction.

Three papers on the Tertiary Fish remains of Australia have already been published, two by F. Chapman and G. B. Pritchard, and a third by F. Chapman, in the years 1904, 1907, and 1917 respectively. Since the latter date, much new material has been acquired by the National Museum, and thus it was considered that the time was opportune to present a resumé and description up to date, of the entire collection, as far as the material will allow.

The synopsis that we furnish at the end of this paper will show that the Australian Cainozoics contain much material of the greatest interest in regard to fossil ichthyology. At the same time it will afford some interesting data in regard to the earlier history of the living Australian fish fauna. It will be seen that the principal genera of the living Australian sharks are represented in the Cainozoic system as far back as Upper Miocene times, probably having at least an antiquity of two million years. Several genera, indeed, are pushed back in their history to at least three or four million years. These are the Grey and the Blue Nurse sharks (*Carcharias*), the Hammerheaded shark (*Sphyrna*), the Bull-dog shark (*Odontaspis*), the Blue Pointer sharks (*Lamna* and *Isurus*) and the Great White shark (*Carcharodon*). The latter in Miocene times reached its acme of gigantism, for the teeth that are found in the Miocene of Eastern and Western Victoria indicate a fish which must have attained a length of nearly a hundred feet.

The occurrence of the genus *Strophodus*, which was first recognised by Professor Ralph Tate from our Australian Tertiaries, is of more than particular interest, for the genus as identified by teeth only (see note *infra* in description of *Strophodus*) is, in the northern hemisphere, represented by species which range from the Middle Jurassic to the lower part of the Upper Cretaceous, whilst

here it seems to be confined to the Miocene and possibly Lower Pliocene.

In the genus *Cestracion* we have in common with some other genera of fossils a remarkable instance where marine organisms have been established in the northern hemisphere until a certain period and have then migrated to the southern hemisphere where they now form part of the characteristic fauna. The genus *Cestracion*, as a northern fossil, is noted as late as the Lower Eocene in England and the Middle Eocene in Belgium. In Australia and New Zealand, this shark evidently existed in some abundance in Miocene times and we also include Patagonia, since Ameghino's *Acrodus* is apparently the same generic form. The latter practically belongs to the Miocene period, and in Australia *Cestracion* extended upwards into Pliocene times. The living species is now found in abundance round the Australian coast (*C. philippi.*)

Amongst the new records we have noted several species of fossil fish which have hitherto been confined to New Zealand Cainozoic deposits. These are *Cestracion coleridgensis*, *C. novo-zelandicus*, and *Carcharias aculeatus*.

Of previously ultra-Australian records we now include the North American *Carcharias collata* and *C. incidens*, the Javan *Carcharias javanus*, the European and Patagonian *Odontaspis rutoti*, and *Hemipristis serra*, the latter being already known from Europe, North America, Patagonia and Java.

The list of new species suggests some noteworthy comments; and, incidentally, indicates the utility of having access to larger collections than hitherto, so that one can judge more clearly as to the limitations of species. Thus *Cestracion longidens* appears to be a good and distinct form and is one which was earlier associated with the better known *C. cainozoicus*. Quite a number of species of the genus *Carcharias* have now been established for the Australian Cainozoics, and one of them, here named *C. victoriae*, is a small form with some of the characters of *C. magna* of Maryland, U.S.A., and this species may prove useful for correlation purposes. In addition to the already described fossil species of the Saw Fish, we here record as new, *Pristis recurvidens*, a Miocene to Lower Pliocene form, from Table Cape, Tasmania, Murray River Cliffs, South Australia, and Beaumaris, Victoria. In *Myliobatis affinis* we have a slenderer and more finely denticulated type of palatal tooth which is separable on these grounds from the Kalimnan *M. moorabbinensis*. The specimens previously referred to this latter species from the Mallee Bores are now transferred to *M. affinis*. Continued research amongst the Batesford beds will probably yield still further interesting fish remains, for we here describe two notable additions from that locality, namely, a spine of an extinct *Myliobatis* of stronger ornament than that of the living Eagle Ray and also an interesting form of the genus *Labrodon* in which the teeth are beautifully preserved.

The occurrence of a tooth of an extinct species of Angel-fish (*Squatina*) from Gippsland is, so far, the sole record of this genus in the Tertiaries of the Australian area.

We have taken the opportunity to figure additional specimens of the characteristic Chimaeroid *Edaphodon*, which is so typical of the fish remains of the remanié beds of Grange Burn and Beaumaris. Another and most remarkable species of the genus is now described as *E. mirabilis.* This appears to represent the final stage of the genus before its extinction, since it is probably the largest-known form and is quite the latest geological record of any *Edaphodon.* A further proof that many of the well-known Australian fishes living round the coast were well established in Miocene times is furnished by the occurrence of a spine of the Cow-fish, *Aracana kershawi*, in the lower beds of Table Cape, Tasmania.

The total number of genera of Cainozoic fishes now known, to the date of this paper, is twenty-eight. The number of species amounts to fifty-nine; of these, there are ten new to science.

Description of Species.

Order PLAGIOSTOMI, Duméril (Sharks and Rays).

Family NOTIDANIDAE, Bonaparte.

Genus **Notidanus**, Cuvier. (Grey sharks.)

NOTIDANUS JENNINGSI, Chapman and Pritchard.

Notidanus jenningsi, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 268, pl. XI., fig. 1, 2 Chapman, 1914, Australasian Fossils, p. 270.

Observations. There has been no fresh occurrence of this species.

Family SPINACIDAE, Müller and Henle.

Genus **Acanthias**, Risso. (Spiny Dog-fishes.)

ACANTHIAS GEELONGENSIS, Chapman and Pritchard.
(Plate IX. fig. 1.)

Acanthias geelongensis. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 269, pl. XI., fig. 15. Chapman, 1914, Australasian Fossils, p. 270.

Observations.—It is interesting to record another occurrence for this rare form, which has already been found in the Fyansford beds at Orphanage Hill, near Geelong. This later formation we regard as an argillaceous phase of the Janjukian. The present occurrence is in the typical Janjukian locality of Bird Rock Cliffs, Torquay. The specimen agrees very closely with the one previously figured and described. The only difference noticed is in the slightly more elevated character of the crown.

Additional occurrence.—Janjukian. From the "Ledge," Bird Rock Cliffs, near Torquay (Nat. Mus. Coll., pres. from the T. S. Hall Coll. by F. A. Cudmore).

Family CESTRACIONTIDAE, Agassiz.

Genus **Cestracion,** Cuvier. (Port Jackson shark.)

CESTRACION CAINOZOICUS, Chapman and Pritchard.

(Plate IX., figs. 2-7.)

Cestracion cainozoicus, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 270, pl. XI., figs. 5-8; pl. XII., fig. 2. Chapman, 1914, Australasian Fossils, pp. 269, 271, 307.

Observations.—In addition to the descriptive remarks given by the above authors, we may note the great variation in the size of the teeth of this, the commonest of the Australian species. A notable distinctive feature of *C. cainozoicus* when compared with the species subsequently referred to, is the solidity and thickness of the tooth. In one or two cases in the Table Cape occurrence we note examples of the rhomboidal and sub-tabulate teeth of the anterior series which cover the interior side of the lower jaw. The upper surface of the teeth, belonging to the median lateral series, often show a concavity, for which there may be two explanations: this may either represent the partial wearing away of the crown in the old forms, or it may be induced by flaking of the upper surface after the teeth were isolated, the polishing, and other abrasion being the result of rolling. In certain cases with rolled specimens, the root surface or inferior face is often irregularly barred or transversely striated, giving it a resemblance to worn teeth of the type of *Myliobatis*; but from an extensive series it is seen that this is the result of the peculiar pattern of the vasodentinal channels which trend transversely across the crown of the tooth. In the description of this species in 1904, it was stated that the surface of the crown "is apparently much smoother than that of the living species," *C. philippi*. A series of over three hundred specimens have been collected from Beaumaris by one of us (F.A.C.) during recent years. The greater number are either worn smooth, or show the sub-median ridge and surface pitting only near the extremities; several, however, are perfectly preserved, showing that *C. cainozoicus* has a similar vermiculate pitting to that seen in *C. philippi*. On the other hand, the teeth of the living species are almost invariably acuminate at the diagonal extremities as distinguished from the more rectangular form of *C. cainozoicus*, and, moreover, in the same species, the median ridge generally shows a parallel and subjacent ridge where the borders of the vermiculae spread out horizontally.

One of the most solid forms of the median series is represented by a specimen measuring 23mm. in length, 12mm. in width and 6.5mm. in thickness; collected by Mr. H. Mathias and presented by him to the National Museum.

The previous record of this species from Curlewis should be deleted, as the specimen is now transferred to *C. longidens*, sp. nov. (see *postea*). A tooth from the Mallee Bores (Bore 8, 210-219ft.) previously referred to this species is now recorded as *C. novo-*

zelandicus (see *postea*); we note that *C. cainozoicus* did not occur in the bores.

It is interesting to note the occurrence in the northern hemisphere of several species of *Cestracion*. *C. falcifer*, Wagner, is found in the Lower Kimmeridgian of Bavaria, *C. sulcatus*, A. S. Woodward, in the Cenomanian of Kent, *C. canaliculatus*, Egerton, in the Cenomanian of south-east England and *C. rugosus*, Agassiz sp., in the Cenomanian of England and the Danian of Holland. Amongst other undetermined species (British Museum) is one from the London Clay of Highgate Archway. From Belgium, *C. duponti*, Winkler is recorded from the Middle Eocene, and there are other species in the Cenomanian and Turonian of Saxony and Bohemia.

Occurrence.—Kalimnan. From the nodule band at the base of the cliffs, Beaumaris, Port Phillip; also from the nodule band at Grange Burn. We regard these deposits as partly remanié from a probable Janjukian horizon, or from one intermediate between that and the Kalimnan. F. Chapman has remarked on similar deposits at Muddy Creek and Grange Burn (1914, Mem. Nat. Mus., No. 5, p. 47) as follows: "The nodule bed, I was at one time inclined to think, represented a remanié deposit of the Janjukian series, but my recent visit convinces me that it is the basal bed of the Kalimnan. It consists, as before stated, of cetacean and turtle bones, fish teeth, etc., and lies embedded in a stiff brown clay. The rolled portion of the deposit is probably derived from the underlying Janjukian, since I discovered in a similar bed on the Muddy Creek a scutum of *Lepas pritchardi*, a fossil only found, hitherto, at Waurn Ponds and Torquay in undoubted Janjukian strata. The brown clay of the nodule bed usually contains typical Kalimnan fossils, thus proving the age of the deposit, and making it without a doubt a conglomeratic basal bed." The following are new localities for this species: Janjukian. Upper and lower beds, Table Cape, Tasmania, (Nat. Mus. Coll., pres. by F. A. Cudmore). Bird Rock Cliffs, Torquay (Nat. Mus. Coll., pres. by Mr. W. J. Parr).

CESTRACION COLERIDGENSIS, Chapman.

(Plate IX., fig. 8.)

(?) *Acrodus rothi*, Ameghino, 1906, Anales del Museo Nacional de Buenos Aires, ser. 3, vol. VIII., p. 177, pl. I., figs. 4, 4*a*, 4*e*, 5*a*.

Cestracion coleridgensis, Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 6, pl. IX., figs. 3*a*, 3*b*.

Observations.—The above species was first described from New Zealand specimens, found in the Mt. Brown series (Miocene) of

1.—For the present, *on the ground of usage*, we are retaining the generic term *Cestracion*, Cuvier (1817), in preference to *Heterodontus*, Blainville (1816), which predates it by one year. The latter name is by some regarded as synonymous with *Heterodon*, Palisot de Beauvois (1800), (an Ophidian), which supersedes it by priority. The difference in spelling, however, would make the two terms distinct.

Coleridge Creek, Trelissick Basin, Canterbury. Quite a fair number of this species occur at Beaumaris, where it is found amongst other fish remains in the material worn out at the base of the cliffs. These specimens from Beaumaris resemble the New Zealand forms in point of size, but are more or less water-worn and in most cases have lost the rugose surface of the crown. One or two, however, from the same locality, show both the median ridge and the roughened surface. A specimen from the lower bed, Table Cape, about half as long again as the average examples, evidently belonging to this species, is in a remarkable state of preservation; the base is much flatter than in *C. cainozoicus* with a sharply projecting rim, whilst the crown has a well-defined median ridge from which proceed a sub-parallel series of vermiculate ridges. Two specimens from the upper or *Turritella* bed at Table Cape are small examples but they exhibit the narrow proportions of the above species and the median coronal keel is very distinct.

The species described by Winkler[2] and A. S. Woodward[3] from the Eocene of Brussels and London respectively, under the name *Cestracion duponti*, Winkler, is represented by a more regularly fusiform type of tooth than in *C. coleridgensis*, and in fact, links up with the Cretaceous forms which more nearly approach the genus *Acrodus*.

From the Patagonian formation of Buenos Aires, Ameghino has figured a closely allied, if not identical, species under the name *Acrodus rothi*. It is a slender form with somewhat undulating margins, but the ornamentation of the coronal surface is more thread-like than in the above species, while it differs in its more depressed crown.

Occurrence.—From beds at the base of the Kalimnan and usually found in the shingle. We have never found this species in situ in the upper beds at Beaumaris. Janjukian. Lower bed, Table Cape, Tasmania (length 20.5mm., width 12mm., height, 4mm.); also from the upper bed at the same locality. Collected from all these localities by F. A. Cudmore and presented by him to the Nat. Museum.

CESTRACION NOVO-ZELANDICUS, Chapman.

(Plate IX., fig. 9.)

"Otoliths, ? *Sargus*," Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 45, pl. VII., fig. 8.

(?) *Acrodus basalduai*, Ameghino, 1906, Anales del Museo Nacional de Buenos Aires, ser. 3, vol. VIII., p. 177, pl. I., figs. 2, 2*a*, 3.

Cestracion novo-zelandicus, Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 7, pl. VII., figs. 8*a*-*c*; pl. IX., figs. 4*a*, *b*, 5*a*, *b*.

Observations.—Amongst the teeth of *Cestracion* found at Beaumaris we have noticed some which were formerly regarded as

2.—Winkler, 1876,[2] p. 17, pl. ii., figs. 1, 2, 3.
3.—A. S. Woodward, 1891, p. 105, pl. iii., fig. 1.

C. cainozoicus that differ from that species by being, not only more oblong, but in having a thinner build and a thicker sub-median ridge. This type of tooth no doubt belongs to the New Zealand *C. novo-zelandicus* which there occurred in the Mt. Brown series, Trelissick Basin. As in the New Zealand specimens, the present series is more closely comparable with the living Port Jackson shark (*C. philippi*) than to the teeth of the common Australian fossil species, *C. cainozoicus*, which, we note, has not so far been found in New Zealand.

It is interesting to note that in the Mallee Bores (Bore 8, 210-219ft.) an anterior lateral crushing tooth of the above species was found in a bed which may be relegated to the top of the Janjukian. This occurrence has an important bearing on the age of the Beaumaris horizon, where we regard the basal beds as probably Upper Miocene. This specimen was previously referred to *C. cainozoicus*, which species did not occur in the Mallee Bores[4].

The teeth figured by Ameghino from the Patagonian formation of Buenos Aires under the name *Acrodus basalduai* appear to belong to the genus *Cestracion* and not to *Acrodus*, *sensu stricto*, on account of the structure seen on the crown. The particular species mentioned agrees in general outline with the New Zealand and Australian form *C. novo-zelandicus*, but the vermiculate structure of the coronal surface is somewhat different.

Dimensions of Beaumaris Examples.—A small specimen: length, 9mm.; width, 4.5mm. A large specimen: length, 15mm.; width, 7mm.

Occurrence.—Base of Kalimnan at Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore). Examples not infrequent.

From the top of the Janjukian in the Mallee Bores (Bore 8, 210-219ft.). This is the specimen figured by Chapman and Gabriel, and is in the National Museum Collection.

CESTRACION LONGIDENS, sp. nov.

(Plate IX., fig. 10.)

Description of Holotype.—Teeth elongate, gently curved; crown gently arcuate; base flatly convex and truncately bevelled to meet the coronal edge. The margin between root and crown is indicated by a sharp edge and immediately above this on the inner or concave side is an articulating groove. The coronal surface of the tooth shows on the unworn ends a strong vermiculate pitting, and along the inner margin at a short distance from the edge runs a low, but fairly conspicuous, ridge, which is also a feature of *C. cainozoicus*.

Dimensions of Holotype.—Length, 30mm., greatest width, 11 mm.; greatest height in the centre, 6mm.

4.—Chapman & Gabriel, 1914, p. 55, pl. x., fig. 55; Chapman, 1916, pl. lxvii., fig. 55.

Observations.—A large number of teeth of the fossil forms of *Cestracion* have generally been referred to *C. cainozoicus*; some of these attain extraordinarily long dimensions as compared with the figured and typical forms known as *C. cainozoicus*. These elongated forms we now separate as a new species; at the same time it will be necessary to state our view of the differential characters of each. In the first place, *C. longidens* is typified by a longer and proportionately narrower tooth and it is comparatively thinner than in *C. cainozoicus*. Another character we observe is that the longitudinal coronal ridge seen in both species is nearer the edge in *C. longidens* and is not so sharply sculptured. Judging from the material at present before us, the size of *C. longidens* seems to range from about 22mm. to 30mm. A specimen from Beaumaris, collected by Mr. W. Kershaw in 1868, has a length of 28.5mm., with a width of 10mm.

Occurrence.—Holotype from Beaumaris; collected and presented to Nat. Museum by Mr. F. A. Singleton. Beaumaris (Nat. Mus. Coll., coll. by the late Mr. W. Kershaw; pres. by the late Mr. W. B. Jennings; also in F.A.C. Coll.). Janjukian. Curlewis, near Geelong (Nat. Mus. Coll., pres. by Mr. A. C. Curlewis).

Genus **Strophodus**, Agassiz.

STROPHODUS EOCENICUS, Tate.

(Plate IX., fig. 11.)

Strophodus eocenicus, Tate, 1894, Proc. Roy. Soc. N.S.W., p. 169, pl. XIII., fig. 6. Dennant and Kitson, 1903, Rec. Geol. Surv. Vict., vol. I., pt. 2, p. 94.

Asteracanthus eocaenicus, Tate sp., Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 271, pl. XI., figs. 3, 4; pl. XII., fig. 1. Chapman, 1914, Australasian Fossils, pages 269, 271, 307.

Observations.—It is a little difficult at first sight to separate some of the more elongated forms of teeth of *Cestracion* from those of *Strophodus*[1], but after examining an extensive series from Beaumaris, we notice some points of difference generally constant.

There was, of course, no difficulty with the larger forms of *Strophodus* teeth, but with the smaller ones we note that the outer edge in *Strophodus* is almost perfectly straight or only slightly concave, the articulating grooves are more pronounced, the crown is flatter, and there is an almost entire absence of the median ridge or keel so prominent a feature on the crown of *Cestracion*. As was pre-

1.—It has hitherto been customary to refer *Strophodus* (teeth only) to the genus *Asteracanthus* (spines only), as in some cases they have been associated, indicating a probable generic relationship. In the present case, no spines have been found, and we revert, therefore, to the genus *Strophodus* for our Australian teeth of that type.

viously pointed out by Chapman and Pritchard[2], the microscopic structure seen in the teeth of *Strophodus* and *Cestracion* respectively is sufficiently marked to make the identification reliable. Some of the finest examples of the teeth of *Strophodus* have been collected by one of us (F.A.C.) from Table Cape, Tasmania, a new locality, and these specimens have helped considerably in the separation and diagnosis of this interesting form. It is worth noting that the colour of these Table Cape specimens is almost jet black, probably due to their being largely replaced by vivianite, and this seems to have been occasioned by their occurrence in an ironstone bed, the *Crassatellites* bed. On the other hand, those found at Beaumaris are partially replaced by vivianite and often show remarkable variegation of greenish-blue to brown.

Teeth referred to *Strophodus* have been recorded from the Inferior Oolite of Lincolnshire (*S. magnus*, Agassiz), and from the Bathonian of Oxfordshire, Wiltshire and other places in England (*S. tenuis*, Ag.). The latter species has occurred in the Brown Jura of Würtemburg. From the Kimmeridgian of the north of France *S. beaugrandi*, Sauvage, has been recorded; several other species occur in the Jurassic of France and Germany, whilst the youngest species of the northern hemisphere, *S. punctatus*, Agassiz, comes from the Cenomanian of Bavaria.

Additional Occurrence.—From the base of the Kalimnan at Beaumaris, where they are somewhat rare. Usually found worn or in a damaged condition (F.A.C. Coll.). Janjukian. From both the upper and lower beds at Table Cape, Tasmania (Nat. Mus. Coll., pres. by F. A. Cudmore).

Family CARCHARIIDAE, Müller and Henle.

Genus **Hemipristis**, Agassiz.

HEMIPRISTIS SERRA, Agassiz.

(Plate IX., fig. 12.)

Hemipristis serra, Agassiz, 1843, Poiss. Foss., vol. III., p. 237, pl. XXVII., figs. 18-30.

Lamna (*Odontaspis*) *hopei*, R. W. Gibbes (non Agassiz), 1849, Journ. Acad. Nat. Sci. Philad., ser. 2, vol. I., p. 198, pl. XXVI., figs. 120-123.

Hemipristis serra, Ag., J. Probst, 1878, Württ. Jahresh., vol. XXXIV., p. 143, pl. 8., fig. 49-57.

Hemipristis serra, Ag., K. Martin, 1887, Samml. geol. Reichs-Mus. Leiden, ser. 1, vol. III., p. 26, pl. II., fig 17.

Hemipristis serra, Agassiz, Smith Woodward, 1889, Cat. Foss. Fishes, Brit. Mus. Nat. Hist., pt. 1, p. 449. Zittel (Eastman), 1902, vol. II., p. 32, fig. 59.

2.—1904, p. 272.

Eastman, 1904, Maryland Geol. Surv. Miocene, p. 90, pl. XXXII., fig. 13*a*, 13*b*, 14*a*. Ameghino, 1906, Anales del Mus. Nac. Buenos Aires, ser. 3, vol. VIII., p. 464, 502. Leriche, 1908, Anales Soc. géol. du Nord, vol. XXXVII., p. 305.

Observations.—It has, for a long time, been the quest of collectors in Australia to find evidences of the above genus, since it is so widely distributed in the Tertiaries of the northern hemisphere, so that the discovery of it by one of us (F.A.C.) in the Murray River Cliffs was of more than ordinary interest. Up to the present the known localities for this species are Würtemberg, which yielded Agassiz' original type of the genus, and other Miocene localities in Italy, Sicily, Malta, Corsica, Switzerland, France, and Austria. In the Miocene of North America, it is very common in South Carolina, Maryland, and Virginia. The Florida phosphate beds contain an abundance of this species, shipments of which are occasionally made to Yarraville, near Melbourne. It has also been recorded as occurring in some numbers in the Patagonian Tertiaries in the neighbourhood of Parana and at the Golfo Nuevo. *H. serra* has also been recorded from the Pliocene of Tuscany and from the Tertiary beds of Ngembak, Java[1], the latter locality being the nearest one to the Australian. There is no doubt of the specimen from the Murray River Cliffs having been found in situ, as it was picked out from the undisturbed fossiliferous marl bed near Morgan, South Australia. This specimen is in a good state of preservation; near the base it is pale ochreous in colour, but approaching the apex it becomes almost opalescent with a pale bluish tint; this colouring is typical of other teeth found in the same bed. It almost exactly matches in size and form Agassiz' figures 28-30 on plate XXVII. of the "Poissons Fossiles." It is interesting to note that a living species of this genus (*H. elongatus*, Klunzinger sp.) is found in the Red Sea.

Dimensions.—Base slightly imperfect, height from the base to apex, 21.5mm.; width, imperfect, 15.5mm.; thickness near the base, 5.5mm. The denticles on the posterior cutting edge number thirteen, on the anterior twenty-two.

Occurrence.—Janjukian. Cliff one mile below Pelican Point, Murray River, left bank, South Australia. Nat. Mus. Coll., pres. by F. A. Cudmore.

Genus, **Galeocerdo,** Müller and Henle. (Tiger sharks.)

GALEOCERDO DAVISI, Chapman and Pritchard.

Notidanus marginalis, Davis (pars), 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 34, pl. VI., fig. 7 (non fig. 8).

Galeocardo sp., 1889, A. S. Woodward, Cat. Foss. Fishes, Brit. Mus. Nat. Hist., pt. 1, p. 167.

1.—This specimen was found in the upper beds at Ngembak, which are regarded as on a Lower Miocene horizon by Dr. Martin. See "Unsere Palæozoologische Kenntniss von Java," 1919, p. 30.

Galeocerdo davisi, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 273. Chapman, 1914, Australasian Fossils, p. 269, 271. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, pl. VI., figs. 7 *a-c*.

Observations.—To the earlier record of the localities given in 1904 (*loc. supra cit.*), we add the locality of the railway cutting at South Yarra, Melbourne, now, unfortunately, inaccessible for collecting purposes. This bed is apparently on the same horizon as the Flemington ironstone beds at the summit of the Janjukian. The two specimens were presented by the late Mr. W. B. Jennings, in 1885. They are decidedly water-worn, and indicate a formation which is either remanié or has been subjected to a great deal of current action.

Additional Occurrence.—Upper Janjukian. South Yarra, Melbourne (Nat. Mus. Coll., pres. by the late Mr. W. B. Jennings).

GALEOCERDO LATIDENS, Agassiz.

Galeocerdo latidens, Agassiz, 1843, Poiss. Foss., vol. III., p. 231, pl. XXVI., figs. 22, 23. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 444. Idem, 1899, Proc. Geol. Assoc., vol. XVI., p. 12, pl. I., figs, 31, 32. Eastman, 1901, Maryland Geol. Surv. Eocene, p. 109, pl. XIV., fig. 8. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 273. Eastman, 1904, Maryland Geol. Surv. Miocene, p. 88, pl. XXXII., fig. 10. Chapman, 1914, Australasian Fossils, p. 271, fig. 131*c*. Priem, 1914, Bull. Soc. géol. France, ser. 4, vol. XIV., p. 378.

Observations.—No new localities have been recorded for this species.

GALEOCERDO ADUNCUS, Agassiz.

Galeocerdo aduncus, Agassiz, 1843, Poiss. Foss., vol. III., p. 231, pl. XXVI., figs. 24-28. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 444. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII (N.S.), pt. 1, p. 274. Eastman, 1904, Maryland Geol. Surv. Miocene, p. 88. pl. XXXII., fig. 11. Chapman, 1914, Australasian Fossils, p. 271. Idem, 1916, Rec. Geol. Surv. Vict., vol. III., pt. 4, p. 339, 379.

Additional Occurrence.—From the top of the Janjukian in the Mallee Bores, Victoria (No. 4, 163-170ft.); Nat. Mus. Coll.

Genus **Carcharias**, Cuvier. (The Grey and the Blue Nurse Sharks.)

CARCHARIAS COLLATA, Eastman.

(Plate IX., figs. 13-16.)

Carcharias collata, Eastman, 1904, Maryland Geol. Surv. Miocene, p. 85, pl. XXXII., figs. 3*a*, 3*b*, 4*a*, 5.

Original Description.—"A species of moderate size, the teeth comparatively stout, with a narrow, usually erect crown, strongly convex on its inner, and slightly so on its outer, face; apex sometimes slightly curved inwards or backwards; coronal edges with extremely minute serrations disappearing towards the base. The enamel at the base of crown extends much lower down in the middle of the outer than on the inner face. The root is considerably elongated, large, and symmetrical."

Observations.—The specimens from Beaumaris agree in the main characters with the teeth described by Eastman (*loc. supra cit.*). Eastman mentions in his description that the coronal edges have extremely minute serrations. These we have failed to detect up to the present, but their absence may be easily accounted for when we consider that the edges are more or less water-worn. We may incidentally mention in regard to this that some specimens of *C. collata* from the type locality of Chesapeake Bay in the collection of one of us (F.A.C.), which were obtained by favour of Mr. Raymond Hibbard, also show no signs of serrations on the coronal edges, probably through erosion.

Practically all the specimens from Beaumaris are of smaller dimensions than the Maryland specimens, but this feature hardly justifies a varietal distinction, especially since specimens in the Hibbard collection are just as small.

For the present we place this species under the genus *Carcharias*, *sensu stricto*, as it differs from the group *Aprionodon* (according to Eastman's description) in having fine serrations on the coronal edges.

The almost horizontal or open V-shaped base and the comparatively short, slender crown makes this species easily separable from worn specimens of *C. aculeatus*.

Occurrence.—Kalimnan. Beaumaris; usually found in the shingle and probably from the nodule bed. Only about a dozen specimens are known to us from this locality. Nat. Mus. Coll., collected and presented by Mr. F. A. Cudmore.

CARCHARIAS VICTORIAE, sp. nov.

(Plate IX., figs. 17, 18.)

Description.— Teeth rather small, root equally proportionate to crown in height, teeth presumably of the upper jaw, shaped as in *G. aculeatus*, in which the crown is sharply curved backwards, but differing in being almost devoid of serrations, except close to the

base. Teeth presumably of the lower jaw, with the crown having less backward curvature and sometimes almost vertical. Serrations absent except near the base. Base of tooth strong, expanded laterally, and with the central notch strongly marked.

Dimensions.—Upper tooth (Table Cape): height, 8mm.; length of base, 11.5mm.; height of crown, 5.5mm.

Tooth from lower jaw (Beaumaris): height, 10mm.; length of base when complete, *circa* 10.5mm.; height of crown, 6.5mm.

Observations.—The Victorian species appears to be nearest *C. magna*, Cope sp.[5]. Some strong points of difference are, however, observable which are here regarded as specific. In our species the crown is not so prominent nor projecting so far back proportionately, and the teeth are never much more than half the height of the Maryland specimens, which were from the Miocene or Calvert formation of Charles Co. near the Patuxent River. In the Nat. Mus. Coll. there are specimens of Cope's species from Florida which correspond with those from Maryland.

Occurrence.—Kalimnan. Several examples from Beaumaris, including co-type; Nat. Mus. Coll., coll. and pres. by F. A. Cudmore. Janjukian. One specimen (co-type) from the upper beds, Table Cape, Tasmania; Nat. Mus. Coll., coll. and pres. by F. A. Cudmore.

Subgenus **Prionodon,** Müller and Henle.

CARCHARIAS (PRIONODON) ACULEATUS, Davis sp.

(Plate IX., figs., 19, 20.)

Galeocerdo aculeatus, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 8, pl. I., figs. 1-3.

Carcharias (Prionodon) aculeatus, Davis sp., 1889, A. S. Woodward, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 440. Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 8, pl. I., figs. 1*a-c*, 2*a*, 2*b*, 3.

Observations.—This species has only within recent years been identified in the Australian Tertiaries, but it is a common form in some horizons, as in the basal beds at Beaumaris. Specimens from the Janjukian series (marly limestones) at Neumerella, near Orbost, East Gippsland, are very well preserved and are identical with Davis' type specimens from the Miocene of Coleridge Gully, Trelissick Basin, New Zealand. A Balcombian example here referred to this species, from the blue marly clays of Grice's Creek, Port Phillip, shows the denticles of the crown to be much finer and closer than usual; but this distinction perhaps hardly warrants a new trivial name.

Concomitantly with the comparative abundance of *C. aculeatus* in the Beaumaris beds, we find a great variation in form, in the one

2.—*Sphyrna magna*, Cope, 1867, Proc. Acad. Nat. Sci. Philad., vol. XIX., p. 142. *Carcharias magna*, Cope sp., Eastman, 1904, Maryland Geol. Surv. Miocene p. 86, pl. XXXII., figs. 6*a*, 6*b*, 7*a*, 7*b*.

extreme the tooth having a stout and broad crown, which is slightly oblique, and in the other the crown being central to the base, nearly upright and quite narrow.

Occurrence.—Kalimnan. From the base of the Kalimnan at Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore). Also an exceptionally large specimen from the same locality collected by Mr. H. Mathias (Nat. Mus. Coll.). Janjukian. Neumerella, near Orbost, East Gippsland (coll. F. Chapman, Nat. Mus.). Mallee Bores (Bore 9, 315-325ft.). Balcombian. From the blue clays at Grice's Creek (Nat. Mus. Coll., pres. by F. A. Cudmore). Clifton Bank, Muddy Creek (F. Chapman Coll.).

CARCHARIAS (PRIONODON) INCIDENS, Eastman.

(Plate IX., fig. 21.)

Carcharias incidens, Eastman, 1904, Maryland Geol. Surv. Miocene, p. 87, pl. XXXII., fig. 8.

Original Description.—"Teeth robust, triangular, prominently serrated along the entire coronal margin on both sides. Posterior margin only slightly concave, the anterior nearly straight. Root deep, not produced beyond the base of the crown on either side

"The unique example on which this species is founded resembles in general form certain species of *Corax* from the Cretaceous, and is readily distinguished from other teeth pertaining to *Carcharias*, the roots of which are expanded and the coronal margins less prominently and completely serrated. The form under consideration also bears some resemblance to that described by Noetling as *Galeocerdo dubius* from the Prussian Eocene (Abh. geol. Specialk. Preussen u. Thüring. Staaten, vol. VI., pt. 3, 1885, p. 97, pl. V., fig. 6). Both faces of the crown are convex, the inner more so than the outer. The total height of the tooth is 14mm., the width 15mm., and the thickness of the crown at the middle of the base 4mm." This tooth came from the Calvert formation (Miocene) at Chesapeake Beach.

Observations.—The tooth which we refer to the above species was at first regarded as a small example of *Carcharodon*, but the decided obliquity of the crown, which gives it a form like that of *Corax*, has suggested its nearer affinity to *Carcharias*. As it almost exactly matches the figure of the above species given by Eastman, we have no hesitation in referring it to the form described by him. Height of tooth from base to apex, measured on the long anterior side, 21mm.; width at base, 19mm.; thickness of crown at the middle of the base, 4mm.

Occurrence.—Janjukian. Red Hill, Shelford (Nat. Mus. Coll., pres. by Mr. J. H. Young).

CARCHARIAS (PRIONODON) JAVANUS, Martin.

(Plate IX., fig. 22.)

Carcharias (Prionodon) javanus, K. Martin 1887, Samml. Geol. Reichs-Mus. Leiden, p. 27, pl. II., fig. 19, 19*a*, 20.

Observations.—Two examples of a narrowly hastate type of tooth with fine shallow edge serrations were found by one of us whilst sorting over a quantity of coarse washing from the Balcombian of Clifton Bank, Muddy Creek. They agree so closely with Martin's species that we have no hesitation in ascribing them to it. The larger of the two co-types figured by Martin measures 12mm. in height; the larger of our specimens measures 9mm. Dr. Martin has remarked on their resemblance to teeth of the living *Carcharias (Prionodon) oxyrhynchus*, Müller and Henle, and we might point out their resemblance also to the anterior teeth of the lower jaw of *Carcharias (Prionodon) glyphis*, Müller and Henle.

Occurrence.—Balcombian. Clifton Bank, Muddy Creek (Nat. Mus. Coll., pres. by F. A. Cudmore).

Genus **Carcharoides**, Ameghino.

CARCHAROIDES TOTUSERRATUS, Ameghino.

Carcharoides totuserratus, Ameghino, 1901, Bol. Acad. Nac. Cienc. Cordoba, vol. XVI., p. 102. Idem, 1906, "Les Formations Sedimentaires du Crétacé Supérieur et du Tertiare de Patagonie," Anales del Museo Nacional de Buenos Aires, ser. 3, vol. VIII., p. 183 (footnote), and woodcut fig. 50. Chapman, 1913, Vict. Naturalist, vol. XXX., p. 142, 143.

Observations.—A single further specimen showing the curved crown but lacking the root.

Additional Occurrence.—Filter Quarries, Batesford (T. S. Hall Coll).

CARCHAROIDES TENUIDENS, Chapman.

cf. *Carcharias (Prionodon) acutus*, non Agassiz, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 274.

Carcharoides tenuidens, Chapman, 1913, Victorian Naturalist, vol. XXX., p. 142, 143, and woodcut. Idem, 1914, Australasian Fossils, p. 270, fig. 131*a*. Idem, 1917, Proc. Roy. Soc. Vict., vol. XXIX. (N.S.), pt. II., p. 136, pl. IX., fig. 3.

Observations.—Several further specimens from Waurn Ponds (T.S.H. Coll.).

Genus **Sphyrna**, Rafinesque. (Hammerhead sharks.)

SPHYRNA PRISCA, Agassiz.

(Plate IX., fig. 23.)

Sphyrna prisca, Agassiz, 1843, Poiss. Foss., vol. III., p. 234, pl. XXVI*a*., figs. 35-50. A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 453. Eastman, 1901, Maryland Geol. Surv. Eocene, p. 110, pl. XIV., fig. 7. Idem. Miocene. 1904. p. 91, pl. XXXII., fig. 15. Chapman and Pritchard. 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 275, pl. XI., fig. 9. Chapman, 1914, Australasian Fossils, p. 270.

Observations.—As Smith Woodward has already pointed out (*loc. supra cit.*), it is almost impossible to separate *Sphyrna* from *Carcharias* on the separate teeth. There are apparently some points of difference, however, as the more defined and equiangular crown in *Sphyrna*, with its fine serrations near the base and its smooth apex. Two, at least, of the examples in the Nat. Mus. Coll. agree in this, one being the plesiotype figured by Chapman and Pritchard, and another presented by F. A. Cudmore.

Additional Occurrence.—Janjukian. Batesford (Nat. Mus. Coll., from the T. S. Hall Coll., pres. by F. A. Cudmore.) Balcombian. Clifton Bank, Muddy Creek (Nat. Mus. Coll., pres. by F. A. Cudmore).

Family LAMNIDAE, Müller and Henle.

Genus **Odontaspis**. Agassiz. (Bull-dog sharks.)

ODONTASPIS CONTORTIDENS, Agassiz.

(Plate IX., fig. 24.)

Lamna (Odontaspis) contortidens, Agassiz, 1843, Poiss. Foss., vol III., p. 294, pl. XXXVII *a*., figs. 17-23.

Odontaspis contortidens, Agassiz, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 366. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 275.

Odontaspis acutissima, Agassiz, Leriche, 1910, Annales Soc. géol. du Nord, vol. XXXIX., p. 327, pl. III., figs. 2-8.

Odontaspis contortidens, Agassiz, Chapman, 1914, Australasian Fossils, p. 269-271, fig. 131b. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 11, text-figs. 1*a*, 1*b*.

Observations.—This species was doubtfully recorded from Batesford by Chapman and Pritchard. It is now definitely proved to occur there. Although a large part of the base is missing in most of the specimens, which, altogether, number sixteen, the crown is beautifully preserved, showing in most cases the striated inner surface, which is strong near the base and dying out at about a third from the apex.

A fine specimen from Grange Burn shows the original basal striations, unlike those previously recorded, which were remarked upon (*loc. supra cit.*) by Chapman and Pritchard as " all more or less worn, and therefore probably derived from the Balcombian." This specimen was presented to the Nat. Museum Coll. by Mr. S. F. Mann. Leriche considers (*loc. supra cit.*) that the teeth figured by Agassiz in his "Poissons fossiles" under the names *Lamna* (*Odontaspis*) *acutissima* and *contortidens* are teeth of the same species from different parts of the jaw.

Additional Occurrence. — Upper Pliocene. Limestone Creek (="Lamna" of Dennant); Nat. Mus. Coll. Janjukian. Batesford (Nat. Mus. Coll., pres, by Mr. J. A. Tonks); 60ft. down, Batesford Quarries (Nat. Mus. Coll., pres by Mr. D. Culliney); Filter Quarries, Batesford (T. S. Hall Coll.). Beach, Rivernooke (T. S. Hall Coll.). From the black clays on the beach half way between Point Addis and Anglesea (T. S. Hall Coll.). Neumerella, near Orbost, East Gippsland (coll. F. Chapman Nat. Mus.). Balcombian. From the yellow clays at Grice's Creek, Port Phillip (Nat. Mus. Coll., pres. by F. A. Cudmore). From the blue clays at Balcombe Bay (Nat. Mus. Coll., pres. by F. A. Cudmore).

Odontaspis incurva, Davis sp.

Lamna incurva, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 17, pl. III., figs. 3-5

Odontaspis incurva, Davis sp., A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 372. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol XVII. (N.S.), pt. 1, p. 276. Chapman, 1914, Australasian Fossils, p. 269,271. Idem, 1918, N.Z. Geol. Surv., Pal. Bull No. 7, p. 13, pl. III., figs. 3-5.

Observations.—As regards this species we have to record additional localities which make this species in Victoria definitely Janjukian as well as Kalimnan. None of the specimens have much of the base preserved.

Additional Occurrence.—(?) Kalimnan. Near the top of cliffs at Morgan, South Australia (Nat. Mus. Coll., pres. by F. A. Cudmore); age of stratum still uncertain. Janjukian. Batesford, near Geelong, 60ft. down (Nat. Mus. Coll., pres. by Mr. D. Culliney); also from the same locality (Nat. Mus. Coll., pres. by Mr. J. A. Tonks). Neumerella, near Orbost, East Gippsland (coll. F. Chapman Nat. Mus.). Clyde Quarry, near Geelong (T. S. Hall Coll.).

Odontaspis elegans, Agassiz sp.

Lamna elegans, Agassiz, 1843, Poiss. Foss., vol. III., p. 289, pl. XXXV., figs. 1-5 (non fig. 6, 7); pl. XXXVIIa., fig. 59 (non fig. 58). R. W. Gibbes, 1849, Journ. Acad. Nat. Sci. Philad., ser. 2, vol.

I., p. 196, pl. XXV., figs. 98-102 (? figs. 96, 97). Dixon, 1850, Geol. and Foss. Sussex, p. 203, pl. X., figs. 28-31. McCoy, 1867, Ann. Mag. Nat. Hist., ser. 3, vol. XX., p. 192. Idem, 1874, in Brough Smyth's Prog. Rept. No. 1, p. 35. Johnston, 1877, Proc. Roy. Soc. Tas. for 1876, p. 86.

Lamna huttoni, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 15, pl. III., fig. 1.

Odontaspis elegans, Agassiz sp., A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 361. Idem, 1891, Geol. Mag., dec. 3, vol. VIII., p. 105. Idem, 1899, Proc. Geol. Assoc., vol. XVI., p. 8, pl. I., figs. 15-18. Eastman, 1901, Maryland Geol. Surv. Eocene, p. 104, pl. XIV., figs. 2*a*, 2*b*, 2*c*, 3*a*, 3*b*, 3*c*. Idem, 1904, ibid., Miocene, p. 79, pl. XXX., figs. 2*a*, 2*b* and 3. Chapman, 1917, Proc. Roy. Soc. Vict., vol. XXIX. (N.S.), pt. 2, p. 137, pl. IX., fig. 4.

Observations.—In well preserved specimens the inner surface of the crown near the base is vertically striated after the manner of *O. contortidens*, from which it differs in its generally larger size and less sinuous contour. There are two specimens from Table Cape, Tasmania, in the Nat. Mus. Coll. (R. N. Atkinson Coll.)

Additional Occurrence.— Janjukian. Batesford, 60ft. down in quarry (Nat. Mus. Coll., pres. by Mr. D. Culliney). From the Umpherstone's Cave, Mt. Gambier (T. S. Hall Coll., pres. to Nat. Mus. by F. A. Cudmore). Red Hill, Shelford (T. S. Hall Coll., pres. to Nat. Mus. by F. A. Cudmore). A doubtful specimen from Bird Rock Cliffs, Torquay (Nat. Mus. Coll., pres. by F. A. Cudmore).

ODONTASPIS ATTENUATA, Davis sp.

Lamna attenuata, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 19, pl. III., fig. 11*a*-*c*.

Odontaspis attenuata, Davis sp., A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 374. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 277, pl. XI., figs. 10, 11. Chapman, 1914, Australasian Fossils, p. 270, 271.

Observations.—Three very fine specimens are here recorded for the first time from Batesford. An additional example from Beaumaris, collected by one of us (F.A.C.), is beautifully preserved.

Additional Occurrence.—Janjukian. 60ft. down, quarry at Batesford (Nat. Mus. Coll., pres. by Mr. D. Culliney). Filter Quarries, Batesford (T. S. Hall Coll.). Bird Rock Cliffs, Torquay (Nat. Mus. Coll., pres. by F. A. Cudmore).

ODONTASPIS CUSPIDATA, Agassiz sp.

(Plate X., figs. 25, 26.)

Lamna cuspidata, Agassiz, 1843, Poiss. Foss., vol III, p. 290, pl. XXXVII*a*. figs. 43-50. Gibbes, 1849, Journ. Acad. Nat. Sci. Philad., ser. 2, vol. I., p. 197, pl. XXV., figs. 103-106.

Odontaspis cuspidata, Agassiz sp., A. S Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 368. Idem, 1899, Proc. Geol. Assoc., vol. XVI., p. 7, pl. I., figs. 12-14. Eastman, 1901, Maryland Geol. Surv. Eocene, p. 105, pl. XIV., figs. 1*a*, 1*b*, 6*a*, 6*b*. Leriche, 1902, Mem. Mus. d'Hist. nat. Belg., vol. V., p. 268, pl. XV., fig. 1-21. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 276, Eastman, 1904, Maryland Geol. Surv. Miocene, p. 78, pl. XXX., figs. 1*a*, 1*b*. Leriche, 1908, Anales Soc. Geol. du Nord, p. 238, 303, pl. IV. Chapman, 1914, Australasian Fossils, p. 269, 271. Priem, 1914, Bull. Soc. Geol. France, ser. 4, vol. XIV., p. 378, 380.

Observations.—In addition to the records of this species previously made by Chapman and Pritchard, we have the good series collected by one of us (F.A.C.) from the upper bed (*Turritella*) of Table Cape, Tasmania. Two of these examples probably represent anterior teeth, and one of them is of an immature type with a very short crown. There are also several with shorter crowns probably representing the intermediate lateral part of the series. In the Table Cape specimens the lateral cusps are very well preserved in almost every case. In the former description of *O. cuspidata* (Chap. and Prit., 1904), *Lamna marginalis*, Davis was inadvertently included in the synonymy, but that species is probably synonymous with *Lamna compressa* and therefore the previous reference of its New Zealand occurrence as *O. cuspidata* should be deleted. (See also Chapman, Geol. Surv. Branch, Dept. Mines, New Zealand, Pal. Bull. No. 7, p. 15).

Additional Occurrence.—In a hard shelly rock near the top of the *Turritella* bed, Table Cape, Tasmania. Janjukian. Nat. Mus. Coll., pres. by F. A. Cudmore.

ODONTASPIS RUTOTI, Winkler sp.

(Plate X., fig. 27.)

Otodus rutoti, T. C. Winkler, 1876, Archiv. Mus. Teyler, vol. IV., pt. 1, p. 4, pl. I., figs. 3 and 4. Vincent, 1876, Ann. Soc. Malacol. Belg., vol. XI., p. 124, pl. VI., figs. 1*a*-*e*.

Odontaspis rutoti, Winkler sp., A. S. Woodward, 1899, Proc. Geol. Assoc., vol. XVI., p. 7, pl. I., figs. 10 and 11.

Odontaspis rutoti, Winkler, Leriche, 1902, Mem. Mus. roy. l'Hist. nat. Belg., vol. II., p. 21, 31, pl. I., figs. 37-44. Idem, 1906, Mem. Soc. géol. du Nord, vol. V., p. 115. Ameghino, 1906, Annales del Museo Nacional de Buenos Aires, ser. 3, vol. VIII., p. 184, 185, 505, pl. I., figs. 10 and 10*a*. Leriche, 1908, Ann. Soc. géol. du Nord, vol. XXXVII., p. 236, pl. III., figs. 13-22.

Odontaspis rutoti, Winkler sp., Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 14 and 15.

Observations.—Ameghino has suggested that the specimen of a shark's tooth from Waurn Ponds referred by Chapman and Pritchard in 1904 to *Lamna bronni* probably belongs to *Odontaspis rutoti*, Winkler sp., but the present authors are still of the opinion that the tooth was correctly identified as that of a *Lamna*. We have now the pleasure of recording a veritable *O. rutoti* from the Miocene (Janjukian) of Table Cape Tasmania. Hitherto the species *O. rutoti* has been recorded from the Lower Eocene in England and Belgium, but in all probability the Patagonian examples of Ameghino are distributed in a formation of later age.

The solitary example before us (here figured) shows tne crown and a little more than half the base of the tooth, and has two well-developed lateral denticles while a third is smaller. In form and general characters it closely matches the figure given by Ameghino (*loc. supra cit.*). The original figures by Winkler show a rather broader crown, but the tooth is fundamentally the same as our specimen.

The bed from whence Ameghino's specimen came is the Lower Juléen, which is nearly at the base of the Patagonian formation. It might be mentioned in passing that associated with the Patagonian examples of *O. rutoti* is *Carcharodon megalodon* (recorded as *C. auriculatus* by Ameghino) which is also found at Table Cape. The echinoids, brachiopods and other shells also show affinities to our Janjukian, so that it is patent to us that the species ranges higher in the southern hemisphere.

Occurrence.—From the lower bed at Table Cape, Tasmania; Nat. Mus. Coll., pres. by F. A. Cudmore.

Genus **Lamna**, Cuvier. (Blue Pointer sharks.)

LAMNA APICULATA, Agassiz.

(Plate X., figs. 28, 29.)

Otodus apiculatus, Agassiz, 1843, Poiss. Foss., vol. III., p. 275, pl. XXXII., figs. 32-35.

Oxyrrhinus woodsii, McCoy, MS., T. Woods, 1862, Geol. Obs. S. Aust., p. 80, two figures.

Oxyrhina enysii, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 28, pl. V., figs. 17*a-c*, 18, 19 and 20.

Oxyrhina subvexa, Davis, 1888, ibid., p. 31, pl. VI., figs. 4*a-c*.

Lamna apiculata, Agassiz sp., Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 278. Chapman, 1914, Australasian Fossils, pages 268, 269, 271, fig. 130*d*. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 13, pl. V., figs. 17*a-c*, 18-20; pl. VI., figs. 4*a-c*.

Observations.—In a former paper it was remarked that the the Kalimnan specimens from Beaumaris were "all worn and probably derived from the Balcombian." We have noticed further the occurrence of several specimens from the same locality which are very well preserved, one being here figured. We are of the opinion that the bed from which they were derived is, if anything, not older than the Upper Miocene.

Additional Occurrence.—Janjukian. Filter Quarries, Batesford (T. S. Hall Coll.; also F. A. C. Coll.); Batesford (Nat. Mus. Coll., pres. by Mr. J. A. Tonks; also pres. by Mr. H. E. Henshaw); 60ft. down, Batesford (Nat. Mus. Coll., pres. by Mr. D. Culliney). Aust. Portland Cement Co. Quarry, Moorabool River (F. A. C. Coll.). Curlewis (Nat. Mus. Coll.). Meredith, Moorabool River (Nat. Mus. Coll., pres. by Mr. J. A. Kershaw). Limestones on township side of mouth of Spring Creek, Torquay (Nat. Mus. Coll., pres. by F. A. Cudmore). Lower beds, Bird Rock Cliffs, Torquay (Nat. Mus. Coll., pres. by F. A. Cudmore). Lower bed, Table Cape, Tasmania (Nat. Mus. Coll., pres. by F. A. Cudmore). Murray River Cliffs, at Morgan, South Australia (Nat. Mus. Coll., pres. by F. A. Cudmore); also 4 miles below Morgan (F. A. C. Coll.). Lower beds, Aldinga, South Australia (Nat. Mus. Coll., pres. by F. A. Cudmore).

LAMNA COMPRESSA, Agassiz.

Lamna compressa, Agassiz, 1843, Poiss. Foss., vol. III., p. 290, pl. XXXVII., figs. 35-42.

Lamna marginalis, Davis, (pars), 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 19, pl. III., figs. 8-10.

Lamna macrota, Agassiz (vel *compressa*), A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 402.

Odontaspis macrota, Agassiz sp., A. S. Woodward, 1899, Proc. Geol. Assoc., vol. XVI., p. 9, pl. I., figs. 19 and 20.

Lamna compressa, Agassiz, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. I, p. 279. Chapman, 1914, Australasian Fossils, pages 269 and 271. Idem, 1916, Rec. Geol. Surv. Vict., vol. III., pt. 4, p. 338 and 379. Idem, 1918, N.Z., Geol. Surv., Pal. Bull. No. 7, p. 15, pl. II., figs. 8*a-c*, 9; pl. IX., figs. 6*a*, *b*, and 7.

Observations.—This species is remarkably rare compared with others of the same genus. We note that one of two additional specimens in the Nat. Mus. Coll., presented by Mr. J. A. Kershaw, F.E.S., Curator of the Nat. Mus., from Grange Burn is, unlike those previously recorded from the locality, remarkably well preserved.

Additional Occurrence. — Upper Pliocene. Limestone Creek (="*Oxyrhina* or *Lamna*" of Dennant); Nat. Mus. Coll. Janjukian. 60ft. down, Batesford (Nat. Mus. Coll., pres. by Mr. D. Culliney). From over 400ft. down and near the bottom of the bore for water in the yards at the abbattoirs in 1919, at Croydon, near Adelaide, S. Australia (Nat. Mus. Coll., pres. by F. A. Cudmore).

LAMNA CRASSIDENS, Agassiz.

Lamna crassidens, Agassiz, 1843, Poiss. Foss., vol. III., p. 292, pl. XXXV., figs. 8--21.

Odontaspis (?) *crassidens*, Agassiz sp., A. S. Woodward, 1889, Cat. Foss., Fishes, Brit. Mus., pt. 1, p. 373.

Lamna crassidens, Agassiz, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 278. Chapman, 1914, Australasian Fossils, p. 269. Priem, 1914, Bull. Soc. géol. France, ser. 4, vol. XIV., p. 378, 380, 382.

Additional Occurrence.—Kalimnan. Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore). Janjukian. A second specimen from Waurn Ponds (Nat. Mus. Coll., pres. by the late Mr. W. Nelson).

LAMNA BRONNI, Agassiz.

Lamna (*Odontaspis*) *bronni*, Agassiz, 1843, Poiss. Foss., vol. III., p. 297, pl. XXXVIIa., figs. 8-10.

Odontaspis acuta, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 22, pl. V., figs. 1 and 2.

Odontaspis bronni, Agassiz, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 360. Idem, 1891, Geol. Mag., dec. 3, vol. VIII., p. III.

Lamna bronni, Agassiz, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 279. Chapman, 1914, Australasian Fossils, p. 269. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 14, pl. V., figs. 1*a*, 1*b*, 2*a-c*; pl. VIII., fig. 3.

Observations.—It is of interest to note that this species occurs in New Zealand in beds of Miocene age, as has been shown by Chapman (*loc. supra cit.*). No additional specimens have occurred since the one referred to in 1904, which is in the Pritchard Coll.

Genus **Isurus,** Rafinesque. (Blue Pointer sharks.)

ISURUS HASTALIS, Agassiz sp.

(Plate X., fig. 30.)

Oxyrhina hastalis, Agassis, 1843, Poiss. Foss., vol. III., p. 277, pl. XXXIV., figs. 3-13, 15-17.

Oxyrhina xiphodon, Agassiz, 1843, ibid., p. 278, pl. XXXIII., figs. 11-17.

Oxyrhina trigonodon, Agassiz, 1843, ibid., p. 279, pl. XXXVII., figs. 17, 18.

Oxyrhina plicatilis, Agassiz, 1843, ibid., p. 279, pl. XXXVII., figs. 14, 15.

Oxyrhina acuminata, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 29, pl. V., figs. 21*a-c*.

(?) *Oxyrhina lata*, Davis, 1888, ibid., p. 32, pl. VI., fig. 5.

Oxyrhina hastalis, Agassiz, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 385. L. Seguenza, 1900, Boll. Soc. Geol. Ital., vol. XIX., p. 484, pl VI., figs. 23-28. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 280, pl. XI., figs. 12-14. Eastman, 1904, Maryland Geol. Surv. Miocene, p. 80, pl. XXX., figs. 5*a*, *b*, 6*a-c*. Ameghino, 1906, Anales del Museo Nacional de Buenos Aires, ser. 3, vol. VIII., p. 179, pl. I., figs. 16, 16*a*, 16*c*, 16*i*. Leriche, 1908, Anales Soc. géol. du Nord, vol. XXXVII., p. 303. Chapman, 1914, Australasian Fossils, p. 268, 269, 271, fig. 130*c*.

Isurus hastalis, Agassiz sp., Chapman, 1917, Victorian Naturalist, vol. XXXIV., No. 8, p. 128. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 17, pl. V., figs. 21 *a-c*; pl. VI., fig. 5. Jordan and Gilbert (pars), 1919, Foss. Fishes South. Calif., Stanford Univ., California, pt. 2, pl. VIII., figs. A, B, and H.

Observations.—Although many additional occurrences are here recorded, the range from Balcombian to Kalimnan remains the same. We have had some little difficulty in separating the teeth of *Isurus hastalis* from those of *Lamna apiculata* which have lost their lateral denticles, but the latter may be distinguished by the relatively greater median thickness along the vertical axis. The colouration in the teeth of *I. hastalis* varies remarkably from blue to brown and yellow. One of the most handsome *I. hastalis* we have seen was collected by the late Dr. T. S. Hall from Murghebuloc, near Geelong. This tooth has a length from base to apex of crown of 75mm., whilst the width at the base is 47mm. The greatest thickness of the tooth is 12.5mm. The shape is elongate triangular, slightly obliquely curved, with the sharp enamel edge of a razor-like

keenness. The colour varies from bluish grey in the centre of the tooth passing into a dark bluish grey towards the edges and apex. The vasodentinal structure is well preserved and shows the openings to the canals as perfectly as in a recent specimen.

Additional Occurrence.—Kalimnan. Black Rock (T. S. Hall Coll.). Janjukian. Aust. Portland Cement Co. Quarry, Moorabool River, near Geelong (F. A. C. Coll.). Section IV*a*., Murgheboluc, near Geelong (Nat. Mus. Coll., from T. S. Hall Coll., pres. by F. A. Cudmore). Bullenmerri, near Camperdown (T. S. Hall Coll.). L. Keilambete, near Colac (Nat. Mus. Coll., col. and pres. by Mr. R. H. Walcott). South Yarra, Melbourne (Nat. Mus. Coll., pres. by the late Mr. W. B. Jennings). 4 miles below Morgan, Murray River Cliffs, South Australia (F. A. C. Coll.). Balcombian. From yellow clays at Grice's Creek (F. A. C. Coll.); also from the shingle on beach where Balcombian clays rest on granite about a mile south of Grice's Creek (F. A. C. Coll.).

ISURUS RETROFLEXUS, Agassiz sp.

(Plate X., fig. 31.)

Oxyrhina retroflexa, Agassiz, 1843, Poiss. Foss., vol. III., p. 281, pl. XXXIII., fig. 10.

Oxyrhina crassa, Agassiz, 1843, ibid., vol. III., p. 283, pl. XXXVII., fig. 16.

Oxyrhina vonhaastii, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 26, pl. IV., figs. 1, 2 (non fig. 3).

Oxyrhina recta, Davis, 1888, ibid., p. 27, pl. V., fig. 14.

Oxyrhina crassa, Agassiz, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 389.

Oxyrhina retroflexa, Agassiz, Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 282. Chapman, 1914, Australasian Fossils, p. 269 and 271.

Isurus retroflexus, Agassiz, sp., Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 18, pl. IV., figs. 1, 2*a*-*c*.

Observations.—A number of new localities are here recorded. The range of this form as at present known, is Janjukian to Kalimnan. There is a magnificent block of Batesford limestone in the National Museum which contains no less than twenty-eight teeth of this species and one tooth of *Carcharodon megalodon*, Charlesworth. It measures twelve by seventeen inches. It is known that several specimens had been extracted by persons interested before it came into the possession of the National Museum, to which it was presented by Mr. W. B. McCann, when the unique value of it was pointed out by one of us (F.C.), while on a holiday in the Geelong district. The great variation in the teeth of a single species is here shown, some of them being of the typical *vonhaasti* form of New Zealand in their strongly curved crown and prolonged roots.

Additional Occurrence.—Janjukian. Bird Rock Cliffs, Torquay (Nat. Mus. Coll., pres. by Mr. W. J. Harris, also by F. A. Cudmore; T. S. Hall Coll.). Waurn Ponds (Nat. Mus. Coll., pres. by Mr. W. Nelson; also T. S. Hall Coll.). Batesford (Nat. Mus. Coll.); Filter Quarries, Batesford (Nat. Mus. Coll., from T. S. Hall Coll., pres. by F. A. Cudmore). Rutledge's, near Geelong (T. S. Hall Coll.). Aust. Portland Cement Co. Quarry, Moorabool River (F. A. C. Coll.). Lower bed, Table Cape, Tasmania (F. A. C. Coll.). Upper strata of Janjukian age at Morgan, Murray River Cliffs, S. Australia (Nat. Mus. Coll., pres. by F. A. Cudmore); also 4 miles below Morgan (low river level), S.A. (F. A. C. Coll.). Curlewis (Nat. Mus. Coll., collected by Mr. R. H. Annear). Flinders (Nat. Mus. Coll., pres. by Mrs. W. D. Gleadall). Green Gully, Keilor, near Melbourne (Miss Irene Crespin Coll.). Filter Quarries, Batesford (Nat. Mus. Coll., pres. by Mr. W. B. McCann).

ISURUS EOCAENUS, A. S. Woodward, sp.

Carcharias (Scolidon) eocaenus, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 436.

Oxyrhina eocaena, A. S. Woodward, 1900, Proc. Geol. Assoc., vol. XVI., p. 11, pl. I., figs. 25, 26. Chapman, 1914, Australasian Fossils, p. 271. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1., p. 282.

Additional Occurrence.—Janjukian. Curlewis (Nat. Mus. Coll., coll. by Mr. R. H. Annear). 4 miles below Morgan, Murray River Cliffs, South Australia (F. A. C. Coll.).

ISURUS MINUTUS, Agassiz sp.

Oxyrhina minuta, Agassiz, 1843, Poiss. Foss., vol III., p. 285, pl. XXXVI., figs. 39-47. Sismonda, 1849, Mem. R. Acad. Sci. Torino, ser. 2, vol. X., p. 44, pl. II., figs. 36-39. O. G. Costa, 1854, Palaeont. Regno. Napoli, pt. 2, p. 85, pl. VII., figs. 52-58.

Oxyrhina fastigiata, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 30, pl. VI., figs. 1-3.

Oxyrhina minuta, Agassiz sp., Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII, (N.S.), pt. 1, p. 283. Chapman, 1914, Australasian Fossils, pp. 269-271. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 17, pl. VI., figs. 1*a*-*c*, 2, 3.

Additional Occurrence.—Janjukian. Bird Rock Cliffs, Torquay (F. Chapman Coll.). Filter Quarries, Batesford (T. S. Hall Coll., pres. Nat. Mus. by F. A. Cudmore). Upper bed, Table Cape (Nat. Mus. Coll., pres. by F. A. Cudmore). Kalimnan. Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore).

ISURUS DESORII, Agassiz sp.

(Plate X., fig. 32.)

Oxyrhina desorii, Agassiz, 1843, Poiss. Foss., vol. III., p. 202, pl. XXXVII., figs. 8-13.

Oxyrhina leptodon, Agassiz, 1843, ibid., p. 282, pl. XXXVII., figs. 3-5.

Oxyrhina grandis, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 30, pl. V., figs. 15, 16.

Oxyrhina desorii, Agassiz, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 382. Idem, 1891, Geol. Mag., dec. 3, vol. VIII., p. 106. L. Seguenza, 1900, Boll. Soc. Geol. Ital., p. 482, pl. V., figs. 1-12. Leriche, 1902, Mem. Mus. d'Hist. nat. Belg., vol. V., p. 275, pl. XVI., figs. 16-31. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol XVII. (N.S.), pt. 1, p. 281. Eastman, 1904, Maryland Geol. Surv. Miocene, p. 79, pl. XXX., fig. 4. Leriche, 1906, Ann. Soc. géol. du Nord, vol. XXXV., p. 299, Idem, 1906, ibid., p. 353, 355.

Isurus (?) *desorii*, Agassiz, Jordan, 1907, Univ. Calif. Publ. Geol. Bull., vol. V., No. 7, p. 112.

Oxyrhina desori (Agassiz), Sismonda, Leriche, 1910, Anales Soc. géol. du Nord, p. 330, pl. III., figs. 14, 15.

Oxyrhina desori, Agassiz, Chapman, 1914, Australasian Fossils, p. 269, 271, Priem, Bull. Soc. Géol. France, ser. 4, vol. XIV., p. 374, 378, 380, 387. *Isurus desori*, Ag. sp., Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 16, pl. V., figs. 15*a-c*, 16*a-c*.

Observations.—Although not abundant in the Victorian Tertiary beds, *Isurus desorii* is well distributed in both the Janjukian and the Kalimnan. In Europe and North America it appears as early as the Lower Eocene, and there is a doubtful Upper Cretaceous record from California by Jordan. It occurs doubtfully in the New Zealand Upper Cretaceous (Danian) but is typically represented there from the Eocene to Miocene. The characters of this species are fairly distinct: thus the base is broader than in *I. retroflexus* and is generally midway in shape between that species and *I. hastalis*. The crown is more elongately triangular than in *I. hastalis*, and is more depressed on the inner surface than in *I. retroflexus*. One of the specimens from the Kalimnan of Grange Burn shows, on the outer coronal face, perforations near the surface caused by what appears to be the reticulum of a boring sponge.

Additional Occurrence.—Bird Rock Cliffs, Torquay (Nat. Mus. Coll., from T. S. Hall Coll., pres. by F. A. Cudmore). Clyde Quarries, Moorabool River (Nat. Mus. Coll. from T. S. Hall Coll., pres.

by F. A. Cudmore). Kawarren Limestone Quarries, Beech Forest (Nat. Mus. Coll., pres. by Mr. A. Short.

Genus **Carcharodon**, Müller and Henle.

CARCHARODON MEGALODON, Charlesworth.

Carcharodon megalodon, Charlesworth (ex. Ag. MS.), 1837, Mag. Nat. Hist., vol. I., p. 225, woodc. fig. 24.

Carcharodon megalodon, Agassiz, 1843, Poiss. Foss., vol. III., p. 247, pl. XXIX.

Carcharodon rectidens, Agassiz, 1843, ibid., p. 250, pl. XXXa., fig. 10.

Carcharodon subauriculatus, Agassiz, 1843, ibid., p. 251, pl. XXXa., figs. 11-13.

Carcharodon productus, Agassiz, 1843, ibid., p. 251, pl. XXX., figs. 2, 4, 6-8.

Carcharodon polygyrus, Agassiz, 1843, ibid., p. 253, pl. XXX., figs. 9-12.

Carcharodon megalodon, Agassiz, Gibbes, 1848, Journ. Acad. Nat. Sci. Philad., ser. 2, vol. I., p. 143, pl. XVIII; pl. XIX., figs. 8, 9. McCoy, 1875, Prod. Pal. Vict., dec. 2, pl. XI., fig. 4. Martin, 1887, Samml. Geol. Reichs-Mus. Leiden, ser. 1, vol. III., p. 23, pl. I., fig. 12. Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 12, pl. II., figs. 1-3. A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 415. L. Seguenza, 1900, Boll. Soc. Geol. Ital., vol. XIX., p. 503, pl. VI., figs. 1-3. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 284.

Carcharodon megalodon, Charlesworth sp., Eastman, 1904, Maryland Geol. Surv. Miocene, p. 82, pl. XXXI., figs. 1*a-c*, 2, 3, 4*a*, 4*b*. Jordan, 1905, Guide to the Study of Fishes, vol. 1., p. 539, fig. 332. Ameghino, 1906, Anales del Museo Nacional de Buenos Aires, ser. 3, vol. VIII., p. 181, fig. 48; pl. II., figs. 21, 21*a*, 21*e*, 22, 22*a*.

Carcharodon chubutensis, Ameghino, 1906, ibid., p. 181, fig. 49.

Carcharodon branneri, Jordan, 1907, Univ. Calif. Publ. Bull. Dept. Geol., vol. V., No. 7, p. 116, fig. 15.

Carcharodon megalodon, Agassiz, Leriche, 1908, Ann. Soc. géol. du Nord, vol. XXXVII., p. 304. Chapman 1914, Australasian Fossils, pages 269, 270, 271. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 19, pl. II., figs. 1*a-c*, 2*a-c*, and 3.

Observations.—We have examined a large tooth from Neumerella, near Orbost, which is nearly equal in size to some gigantic examples from Muddy Creek, Victoria. The height of this tooth

is 115mm., and the width of the root is 90mm. Another tooth of interest, from Beaumaris, has a very undeveloped crown, but the root is large and of abnormal shape and seems to indicate an anterior tooth. In its general form and depressed crown it might easily be mistaken for a species of the Cretaceous genus *Corax*. Height of tooth, 15.5mm.; width of base, 30mm.; (Nat. Mus. Coll., presented by F. A. Cudmore).

Additional Occurrence.—Janjukian. Neumerella, near Orbost, East Gippsland (Nat. Mus. Coll., purchased from Mr. A. Taylor). This specimen came from a railway cutting two miles from Orbost. Batesford, near Geelong (Nat. Mus. Coll., pres. by Mr. J. A. Tonks). Table Cape, Tasmania (Nat. Mus. Coll., pres. by Mr. C. Thatcher).

CARCHARODON AURICULATUS, Blainville sp.

Squalus auriculatus, de Blainville, 1818, Nouv. Dict. d'Hist. Nat., vol. XXVII., p. 384.

Carcharodon auriculatus, Agassiz, 1843, Poiss. Foss., vol. III., p. 254, pl. XXVIII., figs 17-19.

Carcharodon angustidens, Agassiz, 1843, ibid., p. 255, pl. XXVIII., figs. 20-25; pl. XXX., figs. 2, 3. McCoy, 1875, Prod. Pal. Vict., dec. 2, p. 8, pl. XI., figs. 2, 3. Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 9, pl. I., figs. 4-6, non pl. VI., fig. 22.

Carcharodon robustus, Davis, ibid., p. 13, pl. I., fig. 7.

Carcharodon auriculatus, Blainville sp., A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 411. Idem, 1899, Proc. Geol. Assoc., vol. XVI., p. 11. L. Seguenza, 1900, Boll. Soc. Geol. Ital., vol XIX., p. 501, pl. V., figs. 14-18. Eastman, 1901, Maryland Geol. Surv. Eocene, p. 108. Chapman and Pritchard, 1904, Proc. Roy. Soc. Vict., vol. XVII. (N.S.), pt. 1, p. 283.

Carcharodon angustidens, Agassiz, Priem, 1906, Bull. Soc. géol. France, ser. 4, vol. VI., p. 199, pl. VIII., figs. 14, 15. Leriche, 1910, Anales Soc. géol. du Nord, vol. XXXIX., p. 330.

Carcharodon auriculatus, Blainville sp., Chapman, 1914, Australasian Fossils, p. 268, 269, 271, fig. 130*e*. Priem, 1914, Bull. Soc. géol. France, ser. 4, vol. XIV., p. 374, 380.

Carcharodon robustus, Davis, Chapman, 1914, ibid., p. 269.

Carcharodon auriculatus, Blainville sp., Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 18, pl. I., figs. 4*a-c*, 5, 6, 7*a-c*.

Observations.—An exceptionally large specimen of *Carcharodon auriculatus* from the Janjukian of Table Cape (lower bed), Tasmania (Nat. Mus. Coll., pres. by F. A. Cudmore), is equal in size to some

small teeth of *C. megalodon*, but differs in the narrower crown. The length of this tooth, point to base of root is 91.5mm.; width at base of crown, 54.5mm.; approximate width at root, when complete, 59mm. The serrations on the edge of this specimen number 98, 17 of them being on the side denticle near the base.

C. auriculatus was recorded by one of us from the Mallee Bores; the specimens, however, prove not to be this species and the record must be amended (see Chapman, 1916, Rec. Geol. Surv. Vict., vol. III., pt. 4, p. 349, 353, and *antea* p. 14).

Additional Occurrence.—Kalimnan. A well-preserved specimen from Beaumaris; Nat. Mus. Coll., collected by Mr. H. Mathias.

CARCHARODON CARCHARIAS, Linné sp. (Great White Shark.)

Squalus carcharias, Linné, 1758, Syst. Naturae, ed. 10, p. 235.

Carcharodon rondeletii, Müller and Henle, 1841, Syst. Beschreib. Plagiostom, p. 70.

Carcharodon sulcidens, Agassiz, 1843, Poiss Foss., vol. III., p. 254, pl. XXX*a*., figs. 3-7.

Carcharodon rondeletii, Müller and Henle, McCoy, 1882, Prod. Zool., vol. I., dec. 8, p. 19, pl. LXXIV.

Carcharodon angustidens, Agassiz, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 9, pl. VI., fig. 22.

Carcharodon rondeletii, Müller and Henle, A. S. Woodward, 1889, Cat. Foss. Fishes, Brit. Mus., pt. 1, p. 420.

Carcharodon carcharias, Linné, Hutton, 1904, Index Faunae novo-zelandiae, p. 54. Waite, 1904, Mem. N.S.W. Nat. Hist. Club, No. 2, p. 8.

Carcharodon rondeletii, Müller and Henle, E. Ray Lankester, 1906, Extinct Animals, p. 264, 266, fig. 192.

Carcharodon carcharias, Linné Waite, 1907, Rec. Cant. Mus., vol. I., No. 1, p. 6.

Carcharodon arnoldi, Jordan, 1907, Univ. Calif. Publ. Geol. Bull. vol. V., No. 7, p. 114, fig. 13.

Carcharodon riversi, Jordan (pars), 1907, ibid., p. 115, fig. 14*a*, (non fig. 14*b*).

Carcharodon rondeletii, Müller and Henle, Leriche, 1908, Soc. géol. du Nord, vol. XXXVII., p. 304.

Carcharodon carcharias, Linné, Jordan, Tanaka and Snyder, 1913, Cat. Fishes Japan, p. 16.

Carcharodon rondeletii, Müller and Henle, Chapman, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 20, pl. VI., fig. 22; pl. VIII., figs. 1, 2.

Observations.—The edge of the tooth in most of the specimens is gently concave, but in one from between Cowie's Creek and Duck

Ponds, Geelong, the edge near the apex is slightly convex. The teeth of this species are readily distinguished from the older forms like *C. auriculatus* and *C. megalodon* by the distinctly depressed internal surface of the crown. The denticulations also are square-ended and not so deeply incised. It is interesting to note the occurrence of this living species from the Kalimnan. A specimen from the Pleistocene of the West Melbourne Swamp gives the following measurements: height of tooth, 43mm.; width of base, 30mm.

Occurrence.—Pleistocene. West Melbourne Swamp (Nat. Mus. Coll., pres. by Mr. J. H. Gatliff). Between Cowie's Creek and Duck Ponds, Geelong (Nat. Mus. Coll., purchased from Mr. N. Taylor). Kalimnan. Beaumaris (Nat. Mus. Coll., pres. by Mr. H. Mathias). Grange Burn, near Hamilton (Nat. Mus. Coll., pres. by Mr. S. F. Mann).

Family SQUATINIDAE, Müller and Henle.

Genus **Squatina**, Aldrovandi. (Angel-fishes or Monk-fishes.)

SQUATINA GIPPSLANDICUS, sp. nov.

(Plate XI., fig. 47.)

Description.—Tooth strong, somewhat recurved and sharply pointed crown; outer face convex, inner face convex; medially depressed; cutting edges sharp. Base thick, triangular, not so laterally extended as in the living *Squatina squatina*, Linné. Basal view of tooth triangular with a median projection on the inner margin representing the median fold on the inner face of the crown.

Dimensions.—Height of tooth, 11mm.; width at base, 5.5mm.; diameter of base from inner to outer surface, 5mm. Holotype.

Observations.—Compared with the living *Squatina squatina*, the tooth of this species has a longer or higher crown and its flexure is more marked. The base is not so widely extended, owing probably to disintegration, but the generic character of the basal median projection of the crown into the root is very marked. Fossil forms such as that described by Winkler[6] as *Squatina prima* from the Eocene of Belgium have a more extended base and thereby accord more closely with the living species. Probably the nearest related fossil species is *Squatina occidentalis*, Eastman[7] from the Miocene of Plum Point, Maryland; this species, however, differs in having a shorter crown, though the base in its less extent is nearer to the Gippsland fossil species than the European ones. Another species, figured by Ameghino from the Patagonian Tertiaries, namely *S. gigantea*,[8] differs considerably from the present in having a short

6.—*Trigonodus primus* Winkler, 1876, p. 13, pl. i., figs. 18-21.
Squatina prima, Winkler, Leriche, 1902, p. 16, 28, pl. i., figs. 17-22. Idem, 1905, p. 72, 96, 177, pl. iv., figs. 3-5. Idem, 1906, p. 112, 141, 161, 176, 177, pl. vii., figs. 3-5. Idem, 1908,[3] p. 230, pl. iii., figs. 1-5.

7.—1904, p. 71, pl. xxviii., figs. 1*a*, 1*b*.

8.—1906, p. 178, 183, text figs. 45*a*, 45*e*, 45*i*.

heavy crown and extended base. *Trigonodus secundus*, Winkler[9] from the Lower Eocene of Belgium, is a stouter type of tooth but shows a considerable likeness to ours in the flexure of the crown. In the greater height of the crown of *S. gippslandicus* one is at first sight liable to confuse it with *Odontaspis*, but the character of the base is very distinct from that genus.

The occurrence of this genus in the Victorian Miocene is interesting from the fact that it has not been previously recorded as fossil from the Australian region.

Occurrence.—Janjukian. Neumerella, near Orbost, East Gippsland. This was discovered by one of us (F.C.) whilst on a collecting expedition to Neumerella railway workings in 1915. Nat. Mus. Coll.

Family PRISTIOPHORIDAE, Günther.

Genus **Pristiophorus,** Müller and Henle. (Saw shark.)

PRISTIOPHORUS LANCEOLATUS, Davis sp.

(Plate X., fig. 33.)

Lamna lanceolata, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 20, pl. III., figs. 12*a-d*.

Pristiophorus lanceolatus, Davis sp., Chapman, 1917, Proc. Roy. Soc. Vict., vol. XXIX. (N.S.), pt. 2, p. 137, pl. IX., fig. 5. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 20, pl. III., figs. 12*a-d*; pl. IX., fig. 8.

Observations.—In addition to the previous occurrence of this species, it is interesting to record some other specimens which have been recently found. The specimen occurring at Batesford is a typical rostral tooth which has been partially bored by a bone-infesting fungus; this discovery extends the range of the species in Victoria down to the Miocene (Janjukian). For the first time an oral tooth of this species has to be recorded, one having occurred in the Kalimnan beds at Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore). Several further rostral teeth have been found at this locality.

Additional Occurrence.—Kalimnan. McDonald's, Muddy Creek, near Hamilton (Nat. Mus. Coll., pres. by F. A. Cudmore). Janjukian. Batesford (Nat. Mus. Coll., from T. S. Hall Coll., pres. by F. A. Cudmore).

Family PRISTIDAE, Günther.

Genus **Pristis,** Latham. (Saw-fishes.)

PRISTIS CUDMOREI, Chapman.

Pristis cudmorei, Chapman 1917, Proc. Roy. Soc. Vict., vol. XXIX. (N.S.), pt. 2, p. 139, pl. IX., fig. 7.

Observations.—Several further specimens have been found at Beaumaris.

9.—1876, p. 20, pl. ii., figs. 4, 5.

PRISTIS RECURVIDENS, sp. nov.

(Plate X., figs. 34, 35.)

Description (Rostral teeth).—Description of Holotype. Tooth of moderate size compared with living forms; flattened elongate, acuminate, with a sinuous twist or recurving of the tooth towards the apex. The concave edge of the tooth is rounded; the convex and incurved opposite margin is keeled and distinctly sulcated on either face of the keel. Base flattened, oval, and depressed.

Dimensions of Holotype.—Length, 14mm.; width of base, 4.5 mm.; greatest thickness of base, 2mm. Upper bed, Table Cape.

Dimensions of Paratype.—Length, 16mm.; width of base, 5.5 mm.; greatest thickness of base, 3.5mm. Lower bed, Table Cape.

Observations.—The colour of the Table Cape specimens, in common with other fish teeth found in these beds, is of a dark bluish to black, probably owing to the mineralised condition in vivianite. A specimen from the Murray River Cliffs, on the other hand, is quite bleached and is of a pale bone colour.

The above species shows a marked distinction from *P. cudmorei* in its recurved apex, in the keeled convex edge, and in the consequent oval outline in cross-section. We have carefully compared the rostral teeth of recent species, in which we have been kindly assisted by Mr. J. A. Kershaw, F.E.S., Curator of the National Museum, and have come to the conclusion that the variation seen in these living forms does not admit such a departure from the type already known to us as *P. cudmorei* as to warrant our placing the present type of tooth with that species.

Occurrence.—Kalimnan. Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore). Janjukian. Wood's Flat, Murray River Cliffs, South Australia (Nat. Mus. Coll., pres. by F. A. Cudmore). Upper and lower beds, Table Cape, Tasmania (Nat. Mus. Coll., pres. by F. A. Cudmore).

Family TRYGONIDAE, Müller and Henle.

Genus **Trygon**. Adanson. (Sting-rays.)

TRYGON CF. RUGOSUS, Probst sp.

Trygon cf. rugosus, Probst sp., Chapman, 1916, Rec. Geol. Surv. Vict., vol. III., pt. 4, p. 341, 389, pl. LXXVI., fig. 56*a-d*.

Observations.—No further record of this species has been made.

Family MYLIOBATIDAE, Müller and Henle.

Genus **Myliobatis**, Cuvier. (Eagle-rays.)

MYLIOBATIS MOORABBINENSIS, Chapman and Pritchard.

Myliobatis moorabbinensis, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol. XX. (N.S.), pt. 1, p. 60, pl. V., figs. 1-3. Chapman, 1917, Proc. Roy. Soc. Vict., vol. XXIX. (N.S.), pt. 2, p. 139, pl. IX., fig. 8.

Observations.—This species remains a restricted Kalimnan form, since some previous records (op. cit.[10]) have been transferred to a new species (*M. affinis*).

Caudal spines: only fragments found; comparable in their form and ornament with the living *M. australis*, Macleay, but differing in the greater compression of the spine (Nat. Mus. Coll., presented by F. A. Cudmore). Locality: Beaumaris.

MYLIOBATIS AFFINIS, sp. nov.

(Plate X., fig. 36.)

Myliobatis moorabbinensis, pars., Chapman, 1914 (non Chapman and Pritchard, 1904), Proc. Roy. Soc. Vict., vol. XXVII. (N.S.), pt. 1, p. 57, pl. X., fig. 57. Idem, 1916, Rec. Geol. Surv. Vict., p. 339, 353, 355, pl. LXXVI., fig. 57. Idem, 1917, Proc. Roy. Soc. Vict., vol XXIX. (N.S.), pt. 2, p. 139, pl. IX., fig. 8.

Description.—Teeth of median series narrow; marginal articulating ridges thin and sharp; transverse ridges of the inferior surface thin and short. Twelve to fifteen ridges in the space of ten millimetres.

Dimensions.—Holotype from Mallee Bores (Bore 10, 225-230 ft.): Length, 18mm.; width, 5.75mm.; thickness, 2mm.

Paratype from upper beds, Table Cape: Length, 18.5 mm.; width, 4.5mm.; thickness, 2mm.

Paratype from Bird Rock Cliffs, Torquay. Length, 27mm.; width, 6.75mm.; thickness, 2.25mm.

Observations.—The present size and form of the median teeth of this species show it to be usually smaller than *M. moorabbinensis*, whilst the transverse denticulate ridges are more numerous than in that species. The record of *M. plicatilis*, Davis, a New Zealand species, listed by Dennant and Kitson from Table Cape, Tasmania[11], we venture to presume is identical with the above species since no specimens have come under our observation which show the breadth of the the New Zealand form.

It will be seen by the above synonymy that the specimens from Bird Rock Cliffs, Torquay, described by one of us in 1917, we now transfer to this new species (*M. affinis*) under which it stands as a paratype. In the 1917 paper some specimens from the borings in the Mallee were also referred to *M. moorabbinensis*, but they have now been relegated to the above new species.

Occurrence.—Kalimnan. Beaumaris (Nat. Mus. Coll., pres. by F. A. Cudmore). Mallee Bores (Bore 10, 225-230ft.), Nat. Mus. Coll. Janjukian. Paratype from Bird Rock Cliffs, Torquay (Nat. Mus. Coll., pres. by Mr. W. J. Parr). Paratype from upper beds,

10.—Chapman & Gabriel, 1914, p. 57, pl. x., fig. 57. Chapman, 1916, p. 339, 353, 355, pl. lxxvi., fig. 57.

11.—1903, p. 94.

Table Cape, Tasmania (Nat. Mus. Coll., pres. by F. A. Cudmore). From the Mallee Bores (Bore 4, 163-170ft.; Bore 9, 315-325ft.), Nat. Mus. Coll.

MYLIOBATIS PRENTICEI, sp. nov.

(Plate X., fig. 37.)

Description.—Fragment of a caudal spine. The spine, when complete, appears to have tapered more rapidly and therefore to have been much shorter than that of the living *M. australis*, Macleay. The back or upper surface of the spine is more roundly convex and smoother than in the living species, whilst the under surface is more deeply grooved and even more so than in the living and the Kalimnan species, *M. moorabbinensis.* The lateral denticles of the present species are much coarser and stronger than in the living form, and their distal edges are more distinctly serrate. In the living species the denticles number about six in ten millimetres of length, whereas in *M. prenticei* there are five.

Dimensions.—Length of fragment, 15mm.; width at widest end, 6.5mm.; width at narrowest end, 4mm.; greatest thickness, 3mm.

Occurrence.—Janjukian. Waurn Ponds. Collected and presented to the National Museum by Mr. H. J. Prentice, after whom we name the specimen in recognition of his enthusiastic and successful collecting.

MYLIOBATIS TENUICAUDATUS, Hector. (Eagle Ray).

Myliobatis tenuicaudatus, Hector, T.N.Z. Inst., vol. IX., 1877, p. 468, pl. X; Idem, Mem. Harv. Mus. Comp. Zool., vol. XXXVI., 1913, p. 433.

Myliobatis australis, Macleay, P.L.S., N.S.W., vol. VI., 1881, p. 380; McCoy, Prod. Zool. Vict., dec. VII., 1882, pl. LXIII.

Myliobatis tenuicaudatus, Hector, 1921, Waite, Rec. S. Aus. Mus., vol. II., No. 1, p. 34, fig. 48.

Observations.—Both the caudal spines and the palatal teeth of the living Eagle Ray are found in the Pleistocene of the vicinity of Melbourne. They are well preserved, and are identical with those structures in the recent examples.

Occurrence.—Holocene. New Canal Cutting, between Wharf and Fishermen's Bend, Williamstown, depth about 25ft. Nat. Mus. Coll., pres. by Mr. F. McKnight. Spine behind dorsal fin. Pleistocene. West Melbourne Swamp; Mr. W. Kershaw Coll. in Nat. Museum. Also a caudal spine from the same locality; Nat. Mus. Coll. pres. by the late Mr. F. P. Spry. The Kershaw Coll. includes examples of the palatal teeth from West Melbourne Swamp.

Order HOLOCEPHALI. (Chimaeras).

Family CHIMAERIDAE.

Genus **Edaphodon,** Buckland. (Elephant fish.)

EDAPHODON SWEETI, Chapman and Pritchard.

(Plate XI., fig. 38, 39.)

Edaphodon sweeti, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol. XX. (N.S.), pt. 1, p. 61, pl. V., figs. 4-6.

Observations.—From the numerous specimens now in the Collection it is seen that there is a great variation in the mode of preservation of the tritors especially of the vomerine or pre-maxillary bones. There may, indeed, be more than one species besides that described below, but of this we are not yet certain as the material is insufficient for determining the point. We are now figuring a well preserved right palatine from Grange Burn, which Mr. S. F. Mann kindly allowed us to select from a large number of his fossils, and this specimen shows in its comparative shortness its distinction from *E. prenticei.* Another specimen figured and from a new locality, Black Rock, is a pre-maxilla in which the small tritors are very well seen.

Additional Occurrence.—Black Rock (Nat. Mus. Coll., presented by Miss Hilda Neal). From the shingle, presumably derived from the Kalimnan.

EDAPHODON MIRABILIS, sp. nov.

(Plate XI., fig. 40.)

Description.—Holotype based on a right palatine or maxilla. The maxillary bone is very massive as compared with the other Australian fossil form (*E. sweeti*). The symphysial surface is perfectly flat and even. The external surface bears shallow furrows running parallel with the upper anterior margin. The tritors in the specimen pass vertically through the lower to the upper surface of the maxilla, and as the specimen is worn, the superior surface is hollowed out in the tritor-bearing region. The tritors are arranged in the typical manner of *Edaphodon* and are three in number, two inner and one outer (median). The largest is the internal posterior tritor which is bean-shaped or obovate; the internal anterior tritor is paraboloid in form, truncated posteriorly. The external tritor is narrowly oval. The shape of the maxillary bone viewed from the palatal surface is long, triangular, and produced at the outer posterior angle. The outer margin is obliquely directed towards the front of the maxillary bone. The anterior tritor is stepped or re-entrantly angulate against the large posterior internal tritor. The bony structure of the maxillary has an open osseous structure. The tritors are of the typical character, with the medullary canals numerous and projecting above the surface.

Dimensions.—Length of maxilla, 139mm.; greatest width on oval surface, 56mm.; width close to the anterior rounded extremity, 28mm.; greatest height at the posterior end of the maxillary, 49 mm.; length of posterior internal tritor, 51mm.; width, 28mm.; length of anterior internal tritor, 27mm.; width, 16mm.; length of external tritor, 22mm.; width, 8mm.

Observations.—This remarkable specimen differs from the corresponding palatines of *E. sweeti* in its massive proportions and elongated form. It is noteworthy that the nearest species to *E. mirabilis*, both as regards form and position of the tritors, is *E. crassus*, Newton[1], a species which is common in the Cambridge phosphatic deposits and the Upper Greensand of Warminster, and of which a fragment has also been found from the Lower Chalk of Lewes. These English deposits give a range of Albian—Cenomanian—Turonian (Cretaceous). Although the occurrence of gigantic forms of animals in past times indicate their acme and usually subsequent extinction, in this case, although *Edaphodon* itself is extinct (ranging from Cretaceous to Lower Pliocene) the group of the Chimaeroids is now represented by much smaller species (*Chimaera* and *Callorhynchus*).

In making comparisons between the already described *E. sweeti* and the present form we note the following distinctions: (1) *E. mirabilis* is very much thicker and heavier; (2) the prolongation of the maxilla is twice as great as in *E. sweeti*; (3) the tritors in *E. mirabilis* are also longer than in *E. sweeti*, the posterior internal in the latter being subtrigonal in form as against the obovate form in *E. mirabilis*; the internal anterior and the external tritors in *E. sweeti* appear to be of similar dimensions, but in *E. mirabilis* the internal anterior is the larger.

From the fact that the matrix seen in the cavities of the fossil is exactly of the Beaumaris character, that is, a fine cemented ferruginous sand, whilst Cambridge Greensand specimens are generally embedded in a pale to green calcareous glauconitic marl, it is, without doubt, an indigenous specimen and not, as might be suspected by some, to have been "derived" in a non-geological sense.

Occurrence.—Kalimnan. From the shingle bed, derived from the basal portion of the series at Beaumaris. Nat. Mus. Coll., collected and presented by Mr. H. J. Prentice.

Genus **Ischyodus**, Egerton.

Ischyodus mortoni, Chapman and Pritchard.

Ischyodus mortoni, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol. XX. (N.S.), pt. I., p. 63, pl. VI., fig. 6.

Observations.—No further record of this species has been made.

1.—E. T. Newton, 1878, pt. 4, p. 21, pl. vii.

Family LABRIDAE.

Genus **Labrodon,** Gervais. (Wrasses.)

LABRODON BATESFORDIENSIS, sp. nov.

(Plate XI., figs. 41, 42.)

Description.—Lower pharyngeal widely crescentic, with two distinct and prominent rows of rounded or button-shaped teeth, with a clear space between. The extreme margins of the pharyngeal salient, curving outward from the upper part of the lower jaw. Teeth of the forward edge inclined to be wedge-shaped at apex. Surface of teeth covered with a fine, rugosely sculptured enamel cap, of a warm brown colour. The remainder of the pharyngeal consists of a grey ossified substance. Successional teeth are seen on the inner side of the pharyngeal, but not exposed.

Dimensions.—Holotype (lower pharyngeal): width of jaw (incomplete), 26mm.; height, 17mm.; average diameter of teeth, 3.5mm.

Observations.—In its general shape the above species somewhat resembles that of a *Labrus*, but the two effective series of teeth precludes that reference. It must therefore be recorded as a species of *Labrodon.* The absence of angularity in the pharyngeal makes it distinct from the genus *Nummopalatus*, and it differs from *Labrodon confertidens* in the sparsely scattered dentition.

Occurrence.—Janjukian. Batesford (Nat. Mus. Coll., collected by Mr. E. O. Cudmore, pres. by F. A. Cudmore).

LABRODON CONFERTIDENS, Chapman and Pritchard.

Trygon ensifer, Davis (pars), 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 37, pl. VI., figs. 14, 15.

Labrodon confertidens, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol. XX. (N.S.), pt. 1, p. 65, pl. V., fig. 7. Chapman, 1914, Australasian Fossils, p. 271, fig. 131*e*. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 27, pl. IX., fig. 14.

Observations.—*L. confertidens* appears to be a rare species since the only additional specimen coming under our notice is that found on the beach at Portland. It is a worn fragment representing half an upper pharyngeal plate. In this specimen there are about six layers of successional teeth which precludes its reference to *Labrus.*

Additional Occurrence.—Beach at Portland (T. S. Hall Coll., pres. to the Nat. Museum by F. A. Cudmore). ? Janjukian.

Genus **Nummopalatus,** Rouault. (Wrasses.)

NUMMOPALATUS DEPRESSUS, Chapman and Pritchard sp.

(Plate XI., fig. 43.)

Trygon ensifer, Davis (pars), 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 37, pl. VI., figs. 13, 13*a*, 13*b*.

Labrodon depressus, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol. XX. (N.S.), pt. 1, p. 66, pl. V., figs. 8, 9. Chapman, 1914, Australasian Fossils, p. 271. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 27, pl. VI., figs. 13, 13*a*, 13*b*.

Observations.—We have separated this species from *Labrodon* on account of the discovery of more perfect specimens, which show the pharyngeals to be more or less triangular in form. This species appears to be fairly abundant. It is characteristic of the base of the Kalimnan in Victoria. In New Zealand it occurred in the Miocene of Coleridge Gully, Trelissick Basin. In all probability the isolated teeth found in the Mallee Bores (recorded as ? *Chrysophrys*) belong to this species. They came from Bore 3, 201-220ft., and Bore 8, 210-219ft.

Additional Occurrence.—Two specimens from Grange Burn, near Hamilton, Victoria, were presented to the Nat. Museum by Mr. S. F. Mann, one of which is here figured. Additional specimens from Beaumaris have been presented to the Nat. Museum by Mr. B. Ochiltree and Mr. H. J. Prentice. Kalimnan.

Family SPARIDAE.

Genus **Sargus**, Cuvier. (Sea-breams.)

Sargus laticonus, Davis.

Sargus laticonus, Davis, 1888, Trans. Roy. Dubl. Soc., ser. 2, vol. IV., p. 43, pl. VII., figs. 3-8. Chapman, 1917, Proc. Roy. Soc. Vict., vol. XXIX. (N.S.), pt. 2, p. 140, pl. IX., fig. 9. Idem, 1918, N.Z. Geol. Surv., Pal. Bull. No. 7, p. 28, pl. VII., figs. 3-7.

Observations.—There has been no further record of this species but some of the peg-like teeth mentioned in the succeeding description may eventually be referred here.

Genus **Pagrosomus**, Gill, 1893. (Schnapper.)

Pagrosomus auratus, Forster sp.

Sciaena aurata, Forster, in Bloch and Schneider, Ichth., 1801, p. 266.

Chrysophrys unicolor, Quoy and Gaim., Voy. Uran. and Physic., 1824, p. 299.

Pagrus unicolor, Cuv. and Val. Hist. Nat. Poiss., 1824, vol. VI., p. 162. Ten. Woods, 1883, Fish. N.S.W., p. 39, pl. VIII. and frontispiece. Ogil., 1893, Edib. Fish. N.S.W., p. 47, pl. XIII.

Pagrus guttulatus and *P. micropterus*, Cuv. and Val., Hist. Nat. Poiss., 1830, p. 160, 163.

Pagrus latus, Rich., Rep. Brit. Ass., 1842, p. 209.

Chrysophrys gibbiceps, Canestrini, 1869, Arch. Zool. Anat. (2), vol. I., p. 154.

Pagrosomus (and Sparosomus) auratus, Gill, Nat. Acad. Sci., vol. VI., 1893, p. 97, 116, 123. Stead, 1908, Edib. Fish. N.S.W., p. 75, pl. XLII. (young). Waite, 1921, Rec. S. Aus. Mus., vol. II., No. 1, p. 198, fig. 166.

Observations.—Remains of the schnapper are quite common in the Pleistocene deposits round Melbourne. The chief portions generally collected consist of the cranium with its huge supra-occipital and occasionally some vertebral remains. No teeth appear to have been yet collected from these deposits, but some either referrable to this or to the Groper (*Accherodus*) are found in the Kalimnan beds at Beaumaris and these are awaiting further determination.

Occurrence.—Pleistocene. 14 feet from the surface, Cole's Dock Excavations, Flinders Street (Nat. Mus. Coll., pres. by the Hon. A. F. Greeves, M.L.A.) West Melbourne Swamp (Nat. Mus. Coll., pres. by the Dept. of Mines), 13 feet below high water mark, Church Street Bridge Excavations; frontal and parietal bones, also vertebrae (Nat. Mus. Coll., pres. by Mr. A. Lynch).

Family OPLEGNATHIDAE.

Genus **Oplegnathus**, Richardson, 1840. (Knife-Jaw.)

OPLEGNATHUS MANNI, sp. nov.

(Plate XI., fig. 44, 45.)

Description.—Holotype. Lower right pharyngeal. Triangular; the symphysial edge vertical, straight; cutting edge sloping to the back with a slight inward curvature; base thick. Internally concave. This pharyngeal bone is composed of a fasciculated mass of fused, vertically elongated teeth which are exposed at the cutting edge in one continuous row of wedge-shaped enamel caps; beneath these on the external face is another shorter series below which they die out or are covered by the bone of the pharyngeal. Internally the pharyngeal shows the exposed surfaces of the elongated teeth, which appear to grow upward as the cutting edge is worn down. On the basal proximal part of the pharyngeal the small grinding teeth reappear on the exterior in two or three rows.

Dimensions.—Width of basal part of pharyngeal (imperfect), 21mm.; greatest thickness at base, 9mm.; vertical height of pharyngeal, measured along the symphysial surface, 23mm.; greatest depth of exposed teeth on the external surface, 5mm.; average diameter of teeth, 1.5mm.

Comparison.—Through the kind offices of Mr. J. A. Kershaw, F. E. S., Curator of the National Museum, who has made a special study of the Australian living fish faunas, we are enabled to refer this fossil without doubt to the genus *Oplegnathus*. Its occurrence in Australian waters is fully explained in Mr. Kershaw's note which

is here appended and in which he records it from an entirely new locality:—

The genus *Oplegnathus* is represented in Australia by one living species, *O. woodwardi*, Waite, which has been previously recorded from Western and South Australia.

It is interesting, in view of the occurrence in the Kalimnan beds at Grange Burn, Victoria, of a very closely allied species, to record a recent specimen of *O. woodwardi* from Queenscliff, Victoria, obtained in September, 1877, by the late Rev. Dr. J. I. Bleasdale.

The specimen, which is mounted and exhibited in the Australian Fish Gallery is in excellent condition, and compares favorably with Waite's original description and figure.*

Occurrence.—Kalimnan. Grange Burn, Victoria (Nat. Mus. Coll., pres. by Mr. S. F. Mann).

Family SPHYRAENIDAE.

Genus **Sphyraena**, Bloch and Schn. (Snook or Short-finned Pike.)

SPHYRAENA NOVAE-HOLLANDIAE, Günther.

Sphyraena novae-hollandiae, Günther, Waite, 1900, Rec. Aus. Mus., p. 210. Waite, 1921, Fishes S. Aus., Rec. S. Aus. Mus., vol. II., No. 1, p. 85, fig. 128.

Observations.—One example of the cranium of this species was found in the West Melbourne Swamp.

Occurrence.—Pleistocene. West Melbourne Swamp (Nat. Mus. Coll., pres. by Mr. Bromfield).

Family GYMNODONTIDAE.

Genus **Diodon**, Linné. (Porcupine Fish.)

DIODON FORMOSUS, Chapman and Pritchard.

Diodon formosus, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol. XX. (N.S.), pt. 1, p. 66, pl. VI., figs. 1-3; pl. VII.; pl. VIII., figs. 1-7. Chapman, 1914, Australasian Fossils, p. 270, 271, fig. 131*f*. Idem, 1916, Rec. Geol. Surv. Vict., vol. III., pt. 4, p. 343, 379.

Observations.—This species is here recorded from the Janjukian for the first time. The specimen from Curlewis probably represents the lower jaw; only the palatal portion, showing ten platès, is left.

A fine upper jaw from Grange Burn was presented by Mr. W. Greed; it gives the following measurements:

Dimensions.—Lateral width, 65mm.; base to front, 47mm.; width of palate, 33.5mm.; depth of palate, 34.5mm.; number of plates: only six visible.

Additional Occurrence.—? Janjukian. In the shingle at Balcombe Bay (Nat. Mus. Coll., pres. by F. A. Cudmore). Janjukian. Curlewis (Nat. Mus. Coll., pres. by Mr. A. Curlewis). At the top of the Janjukian in the Mallee Bores (Bore 5, 175-189ft.); Nat. Mus. Coll.

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* Rec. Aust. Mus., III., 1900, p. 212, pl. xxxvii.

DIODON CONNEWARRENSIS, Chapman and Pritchard.

Diodon connewarrensis, Chapman and Pritchard, 1907, Proc. Roy. Soc. Vict., vol XX. (N.S.), pt. 1, p. 69, pl. VIII., figs. 8-10.

Observations.—There has been no further record of this species.

Family OSTRACIONTIDAE.

Genus **Aracana**, Gray, 1838. (Cow-fish.)

ARACANA KERSHAWI, sp. nov.

(Plate XI., fig. 46.)

Description.—Holotype. Dermal spine, probably from the dorsal carina. Triangular, strongly compressed, recurved towards the apex, base expanded; surface with few strong ridges which occasionally coalesce and bifurcate towards the base.

Dimensions.—Height, 17mm.; width at base, 11.5mm.; width at middle, 7mm.

Comparisons.—The species, *Aracana aurita*, Shaw[12], which is found in Victorian waters has a more delicately structured spine, being smaller, more backwardly recurved and with the edges twice as fine. We are indebted to Mr. J. A. Kershaw, F.E.S., Curator of the National Museum, for the generic determination of this interesting fossil, and we have much pleasure in naming the new species after him.

Observations.—This appears to be the first recorded occurrence of the genus in fossil deposits. As regards fossil representatives of the family, a well preserved fish from the Upper Eocene of Monte Bolca is figured by Agassiz[13] under the name *Ostracion micrurus*; but this does not seem related to the Australian members of the family since it shows a prominent dorsal fin.

Occurrence.—Janjukian. Lower bed, Table Cape, Tasmania (Nat. Mus. Coll., pres. by F. A. Cudmore).

Acknowledgments and Note.

We desire to thank Mr. J. A. Kershaw, F.E.S. Curator of the National Museum, for his valuable aid in comparing some of the fossil forms with those of the living fishes.

To Mr. F. A. Singleton, M.Sc., of the Melbourne University, we are under obligations for the opportunity of describing the holotype of *Cestracion longidens*, which he has now presented to the National Museum.

12.—*Ostracion aurita*, Shaw, 1798, Nat. Misc., vol. ix., pl. cccxxxviii., Idem, 1804, Gen. Zool., vol. v., p. 429, pl. clxxiii.
Aracana aurita, Shaw, sp.; Waite, 1921, Rec. S. Aust. Mus., vol. ii., No. 1, p. 193, 322.

13.—Poiss. Foss., vol. ii., 1833-44, pt. 1, p. 17; pt. 2, p. 263, pl. lxxiv.

The enthusiastic collecting of one of our younger geological workers, Mr. H. J. Prentice, has enabled us to deal with two interesting forms, *Myliobatis prenticei* and *Edaphodon mirabilis*.

Mr. J. E. Dixon has placed us under further obligation by submitting to us several interesting specimens from his fossil collection.

Miss Irene Crespin, B.A., has kindly allowed us to include her recent discovery of a tooth of *Isurus retroflexus* at Green Gully.

Since the T. S. Hall Collection is frequently referred to, we must state that this is included in the Cudmore private collection.

DISTRIBUTION OF SPECIES.

FAMILIES.	SPECIES.	RANGE.	LOCALITIES.
	Order PLAGIOSTOMI, *Duméril.*		
Notidanidae	*Notidanus jenningsi*, Ch. & Pr.	Kalimnan	Beaumaris.
Spinacidae	*Acanthias geelongensis*, Ch. & Pr.	Janjukian	Bird Rock Cliffs. Orphanage Hill.
Cestraciontidae	*Cestracion cainozoicus*, Ch. & Pr.	Janj. to Kal	Bird Rock Cliffs. Upper and lower beds, Table Cape. Murgheboluc. Warranooke. Grange Burn. Beaumaris.
,,	,, *coleridgensis*, Chapman	Janj. to Kal.	Table Cape (Upper and Lower). Beaumaris.
,,	,, *novo-zelandicus*, Chapman	Janj. to Kal.	Mallee Bores. Beaumaris.
,,	,, *longidens*, sp. nov.	Janj. to Kal.	Curlewis. Beaumaris.
,,	*Strophodus eocenicus*, Tate	Janj. to Kal.	Table Cape (Upper and Lower). Moorabool River. Beaumaris.
Carchariidae	*Hemipristis serra*, Ag.	Janjukian	Murray River Cliffs, S.A.
,,	*Galeocerdo davisi*, Ch. & Pr.	Janj. to Kal.	Gellibrand Coast Sections. South Yarra. Beaumaris. Grange Burn.
,,	,, *latidens*, Agassiz	Kalimnan	Grange Burn. Beaumaris.
,,	,, *aduncus*, Agassiz	Janj. to Kal.	Mallee Bores. Beaumaris.
,,	*Carcharias collata*, Eastman	Kalimnan	Beaumaris.
,,	,, *victoriae*, sp. nov.	Janj. to Kal.	Table Cape (Upp.). Beaumaris.
,,	,, (*Prionodon*) *aculeatus*, Davis sp.	Balc. to Kal.	Clifton Bank. Muddy Creek. Grice's Creek. Mallee Bores. Neumerella. Beaumaris.

Distribution of Species—*continued.*

FAMILIES.	SPECIES.	RANGE.	LOCALITIES.
Carchariidae	,, (,,) *incidens*, Eastman	Janjukian	Red Hill, Shelford.
,,	,, (,,) *javanus*, Martin	Balcombian	Clifton Bank, Muddy Creek.
,,	*Carcharoides totuserratus*, Ameghino	Janjukian	Waurn Ponds. West of Rocky Point, Torquay. Batesford.
,,	,, *tenuidens*, Chapman	Janjukian	Waurn Ponds.
,,	*Sphyrna prisca*, Agassiz	Balc. to Janj.	Clifton Bank, Muddy Creek. Batesford. Orphanage Hill.
Lamnidae	*Odontaspis contortidens*, Agassiz	Balc. to Upper Pliocene	Balcombe Bay. Grice's Creek. Muddy Creek (Low.). Bird Rock Cliffs. Batesford. Waurn Ponds. Fyansford. Moorabool Valley. Belmont. Bet. Pt. Addis and Anglesea. Coast Section, Castle Cove, Aire River. Beach, Rivernooke. Neumerella. Aldinga (Low.). Grange Burn. Beaumaris. Limestone Creek.
,,	,, *incurva*, Davis sp.	Janj. to Kal.	Waurn Ponds. Batesford. Clyde, near Geelong. Warranooke. Neumerella. Morgan, S.A. Grange Burn. Beaumaris.
,,	,, *elegans*, Agassiz sp.	Janjukian	Waurn Ponds. Batesford. Red Hill, Shelford. Fyansford. ? Bird Rock Cliffs. Mt. Gambier, S.A.
,,	,, *attenuata*, Davis sp.	Janj. to Kal.	Waurn Ponds. Batesford. Belmont. Bird Rock Cliffs. Aldinga (Low.), Beaumaris.

Distribution of Species—*continued.*

FAMILIES.	SPECIES.	RANGE.	LOCAILTIES.
Lamnidae	,, *cuspidata*, Agassiz sp.	Janj. to Kal.	Cape Otway. East of Gellibrand River. Table Cape (Upp.). Grange Burn. Beaumaris.
,,	,, *rutoti*, Winkler sp.	Janjukian	Lower bed, Table Cape.
,,	*Lamna apiculata*, Agassiz sp.	Balc. to Kal.	Balcombe Bay. Muddy Creek (Low.). Bird Rock Cliffs. Danger Pt., Torquay. Moorabool River. Batesford. Meredith. Waurn Ponds. Nine miles west of Casterton. Gellibrand Coast Section. Table Cape (Low.). Morgan and four miles below Morgan. Mt. Gambier. Aldinga (Low.). Grange Burn. Beaumaris.
,,	,, *compressa*, Agassiz	Janj. to Kal.	Batesford. Mallee Bores. Warranooke. Croydon Bore, S. Aus. Table Cape. Beaumaris. Grange Burn.
,,	,, *crassidens*, Agassiz	Balc. to Kalimnan	Balcombe Bay. Muddy Creek (Low.). Bird Rock Cliffs. Waurn Ponds. Morgan. Beaumaris.
,,	,, *bronni*, Agassiz	Janjukian	Waurn Ponds.
,,	*Isurus hastalis*, Agassiz sp.	Balc. to Kal.	Balcombe Bay. Muddy Creek (Low.). Grice' Creek. Coast south of Grice's Creek. Moorabool River. Murgheboluc. Bullenmerri. L. Keilambete. South Yarra. Leigh River, Shelford. Mitchell River, Bairnsdale. Four miles below Morgan. Beaumaris. Grange Burn. Black Rock.

Distribution of Species—*continued.*

FAMILIES.	SPECIES.	RANGE.	LOCALITIES.
Lamnidae	,, *retroflexus*, Agassiz sp.	Janj. to Kal.	Bird Rock Cliffs. Waurn Ponds. Batesford. Rutledge's. Moorabool River. Curlewis. West of Gellibrand River. Nine Miles west of Casterton. Morgan and four miles below Morgan. Table Cape (Low.). Grange Burn. Beaumaris.
,,	,, *eocaenus*. A. S. Woodward sp.	Janj. to Kal.	Curlewis. Four Miles below Morgan. Grange Burn. Beaumaris.
,,	,, *minutus*, Agassiz sp.	Balc. to Janj.	Muddy Creek (Low.). Bird Rock Cliffs. Batesford. Table Cape (Upp.). Waurn Ponds. Belmont. East of Gellibrand River. Grange Burn. Beaumaris.
,,	,, *desorii*, Agassiz sp.	Janj. to Kal.	Bird Rock Cliffs. Waurn Ponds. Clyde. Kawarren. Birregurra. Grange Burn. Beaumaris.
,,	*Carcharodon megalodon*, Charlesworth	Balc. to Kal.	Muddy Creek (Low.). Bird Rock Cliffs. Grange Burn lower limestones. Waurn Ponds. Batesford. Native Hut Creek. Neumerella. Table Cape (? Low.). Grange Burn. Beaumaris.
,,	,, *auriculatus*, Blainville	Janj. to Kal.	Waurn Ponds. Bird Rock Cliffs. Rocky Pt., Spring Creek. Casterton. Table Cape (Low.). Nine miles west of Casterton. Grange Burn. Beaumaris.

Distribution of Species—*continued.*

FAMILIES.	SPECIES.	RANGE.	LOCALITIES.
Lamnidae	,, *carcharias*, Linné	Kal. to Pleistocene (also living)	Grange Burn. Beaumaris. West Melbourne Swamp. Between Cowie's and Duck Ponds.
Squatinidae	*Squatina gippslandicus*, sp. nov.	Janjukian	Neumerella.
Pristiophoridae	*Pristiophorus lanceolatus*. Davis sp.	Janj. to Kal.	Batesford. Macdonald's, Muddy Creek. Beaumaris.
Pristidae	*Pristis cudmorei*, Chapman	Kalimnan	Beaumaris.
,,	,, *recurvidens*, sp. nov.	Janj. to Kal.	Murray River Cliffs. Table Cape (Upp.) Beaumaris.
Trygonidae	*Trygon* cf. *rugosus*, Probst sp.	Janjukian	Mallee Bores.
Myliobatidae	*Myliobatis moorabbinensis*, Chap. & Prit.	Kalimnan	Beaumaris.
,,	,, *affinis*, sp. nov.	Janj. to Kal.	Bird Rock Cliffs. Table Cape (Upp.). Mallee Bores (Janj. to Kal.). Beaumaris.
,,	,, *prenticei*, sp. nov.	Janjukian	Waurn Ponds.
,,	,, *tenuicaudatus*, Hector	Pleistocene to Holocene (also living)	West Melbourne Swamp. Williamstown.
	Order HOLOCEPHALI.		
Chimaeridae	*Edaphodon sweeti*, Chap. & Prit.	Kalimnan	Grange Burn. Beaumaris. Black Rock.
,,	,, *mirabilis*, sp. nov.	Kalimnan	Beaumaris.
,,	*Ischyodus mortoni*. Chap. & Prit.	Janjukian	Table Cape (Upper bed).

Distribution of Species—*continued.*

FAMILIES.	SPECIES.	RANGE.	LOCALITIES.
	Order PHYSOCLYSTI.		
Labridae	*Labrodon confertidens*, Chap. & Prit.	Kal. (&? Janj.)	Portland Beach (? Janj.). Grange Burn
,,	,, *batesfordiensis*, sp. nov.	Janjukian	Batesford.
,,	*Nummopalatus depressus*, Chap. & Prit. sp.	Kalimnan	Grange Burn. Beaumaris.
Sparidae	*Sargus laticonus*, Davis	Janjukian	Batesford.
,,	*Pagrosomus auratus*, Forster sp.	Pleistocene (also living)	West Melbourne Swamp. Church St. Bridge. Flinders St.
Oplegnathidae	*Oplegnathus manni*. sp. nov.	Kalimnan	Grange Burn.
Sphyraenidae	*Sphyraena novae-hollandiae*, Günther	Pleistocene (also living)	West Melbourne Swamp.
Gymnodontidae	*Diodon formosus*, Chap. & Prit.	Janj. to Kal.	Curlewis. Mallee Bores. Balcombe Bay (? Janj.). Grange Burn. Beaumaris.
,,	,, *connewarrensis*, Chap. & Prit.	Janjukian	Lake Connewarre.
Ostraciontidae	*Aracana kershawi*, sp. nov.	Janjukian	Lower bed, Table Cape.

Chronological List of Species.

The following species is restricted to the Balcombian:

Carcharias (Prionodon) javanus, Martin.

The following species ranges from the Balcombian to the Upper Pliocene:

Odontaspis contortidens, Agassiz.

The following species range from the Balcombian to the Kalimnan:

Carcharias (Prionodon) aculeatus, Davis sp.
Lamna apiculata, Agassiz sp.
Isurus hastalis, Agassiz sp.
Carcharodon megalodon, Charlesworth.
Lamna crassidens, Agassiz.

Two species range from the Balcombian to the Janjukian:

Sphyrna prisca, Agassiz.
Isurus minutus, Agassiz sp.

Sixteen species are restricted to the Janjukian:

Acanthias geelongensis, Chapman and Pritchard.
Hemipristis serra, Agassiz.
Carcharias (Prionodon) incidens, Eastman.
Carcharoides totuserratus, Ameghino.
Carcharoides tenuidens, Chapman.
Odontaspis elegans, Agassiz sp.
Odontaspis rutoti, Winkler sp.
Lamna bronni, Agassiz.
Trygon cf. *rugosus*, Probst sp.
Myliobatis prenticei, sp. nov.
Ischyodus mortoni, Chapman and Pritchard.
Labrodon batesfordiensis, sp. nov.
Sargus laticonus, Davis.
Diodon connewarrensis, Chapman and Pritchard.
Aracana kershawi, sp. nov.
Squatina gippslandica, sp. nov.

Twenty species range from the Janjukian to the Kalimnan:

Cestracion cainozoicus, Chapman and Pritchard.
Cestracion coleridgensis, Chapman.
Cestracion novo-zelandicus, Chapman.
Cestracion longidens, sp. nov.
Strophodus eocenicus, Tate.
Galeocerdo davisi, Chapman and Pritchard.
Galeocerdo aduncus, Agassiz.
Carcharias victoriae, sp. nov.
Odontaspis incurva, Davis sp.
Odontaspis attenuata, Davis sp.
Odontaspis cuspidata, Agassiz sp.
Isurus retroflexus, Agassiz sp.

Isurus eocaenus, A. S. Woodward sp.
Isurus desorii, Agassiz sp.
Carcharodon auriculatus, Blainville.
Pristiophorus lanceolatus, Davis sp.
Pristis recurvidens, sp. nov.
Myliobatis affinis, sp. nov.
Diodon formosus, Chapman and Pritchard.
Labrodon confertidens, Chapman and Pritchard.

One species ranges from the Janjukian to the Upper Pliocene:
Lamna compressa, Agassiz.

Nine species are restricted to the Kalimnan:
Notidanus jenningsi, Chapman and Pritchard.
Galeocerdo latidens, Agassiz.
Carcharias collata, Eastman.
Pristis cudmorei, Chapman.
Myliobatis moorabbinensis, Chapman and Pritchard.
Edaphodon mirabilis, sp. nov.
Edaphodon sweeti, Chapman and Pritchard.
Nummopalatus depressus, Chapman and Pritchard.
Oplegnathus manni, sp. nov.

One species ranges from the Kalimnan to the Pleistocene and is living still in Australian seas:
Carcharodon carcharias, Linné sp.

Three species occur in the Pleistocene and are still living in Australian seas:
Myliobatis tenuicaudatus, Hector. (also in Holocene.)
Pagrosomus auratus, Forster sp.
Sphyraena novae-hollandiae, Günther.

With regard to the Kalimnan occurrences it is probable that some of the fossils have been derived from the older beds.

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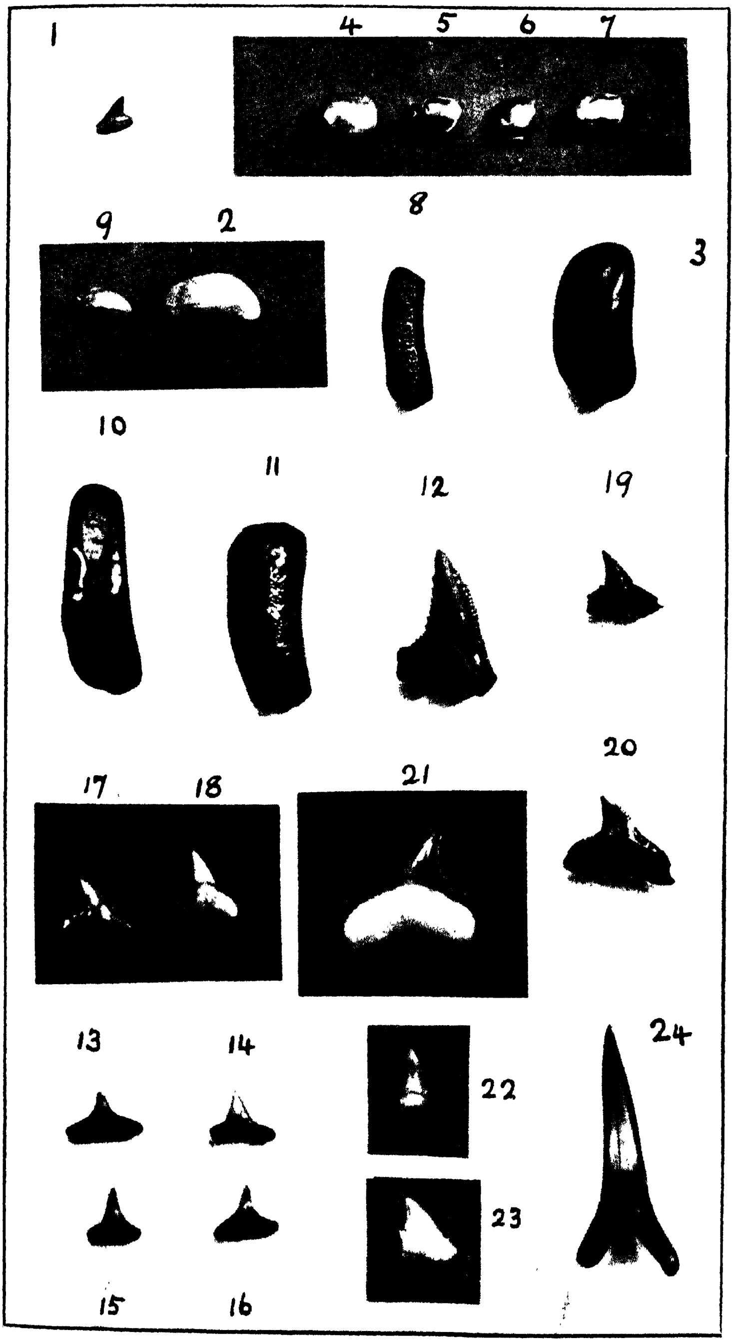
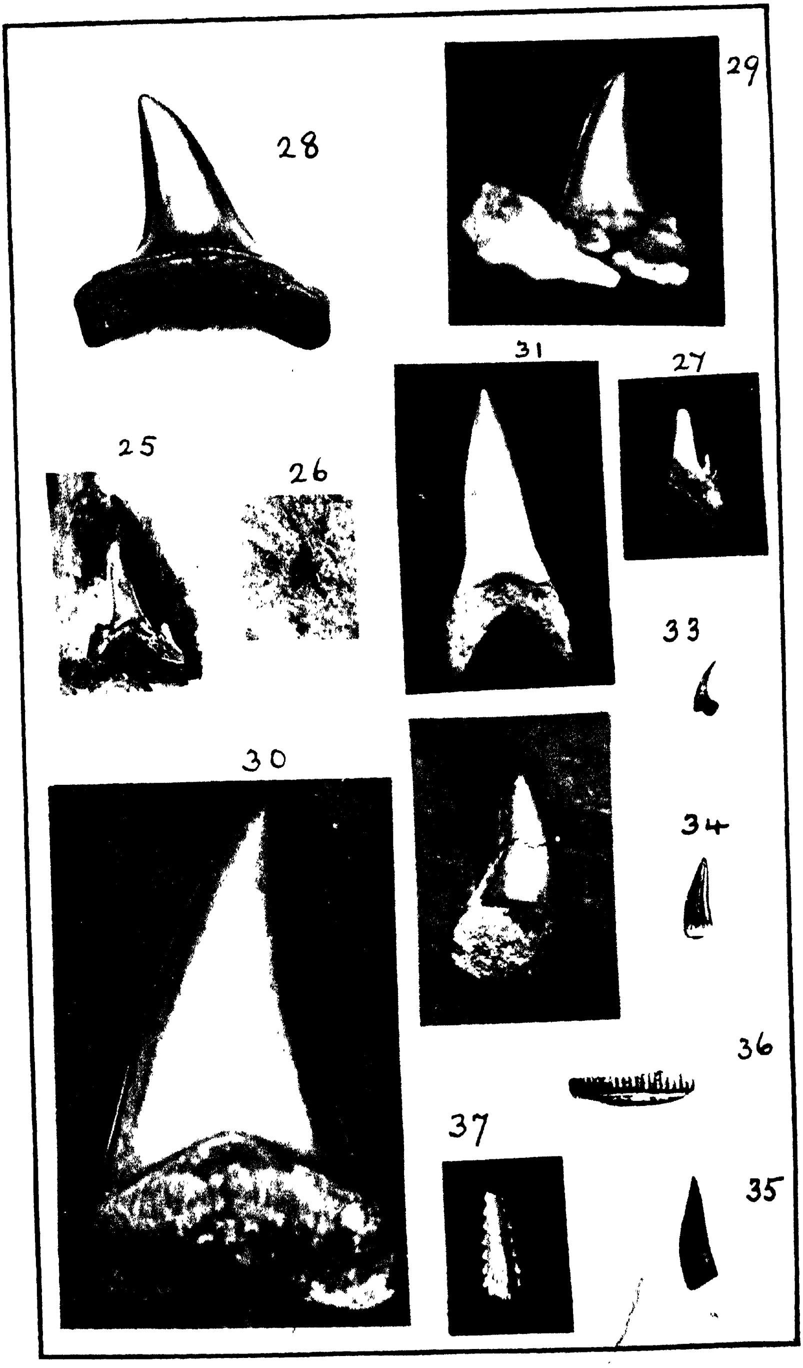


F. C. Photo

Australian Cainozoic Fish Remains



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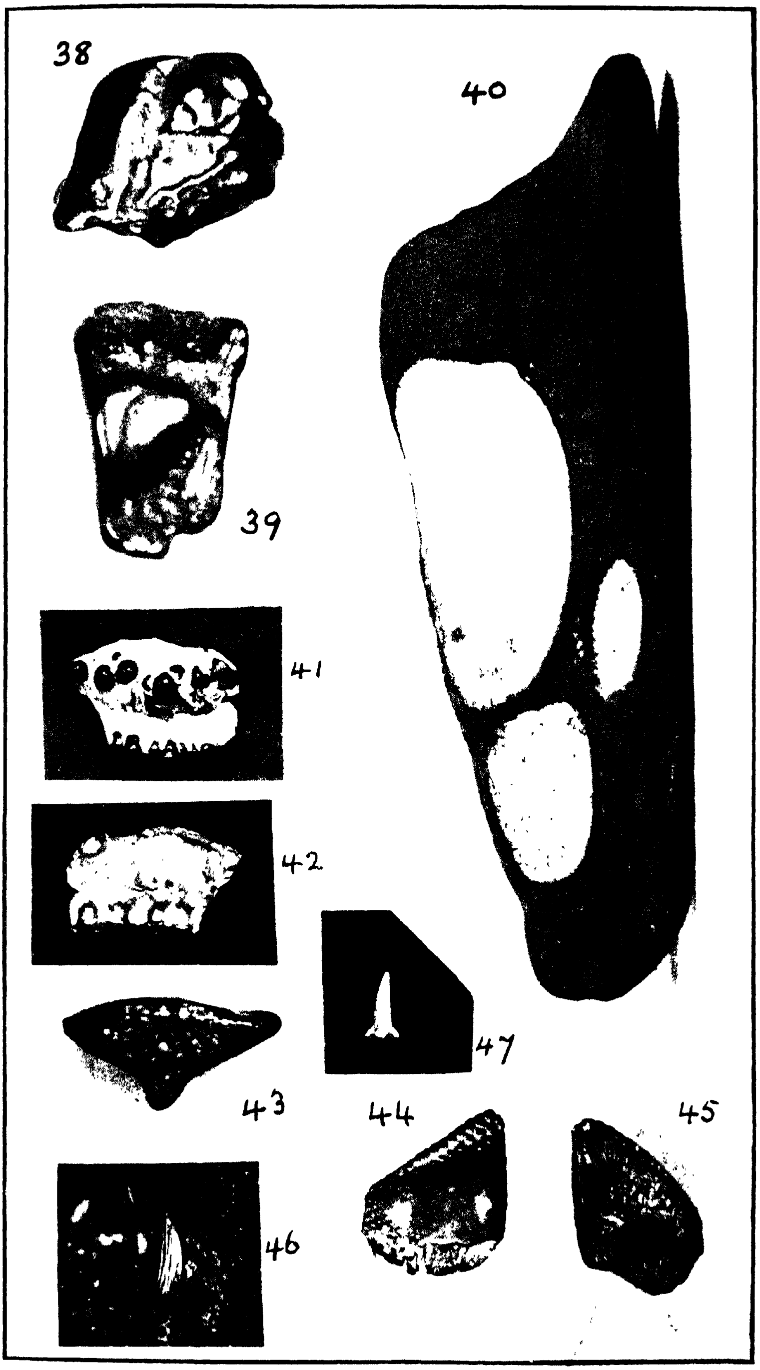
Australian Cainozoic Fish Remains



F. C. Photo

Australian Cainozoic Fish Remains

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. II., 1924.]

ART. X.—*The Geology of the Coimadai Area, Victoria. with special reference to the Limestone Series.*

BY ARTHUR L. COULSON, M.SC.

(With Plate XII., and 1 Text fig.)

[Read 13th December, 1923.]

Contents.

Introduction and Physiography.

The district, which is described and mapped, embraces portions of the parishes of Coimadai and Merrimu in the county of Bourke in the south central region of Victoria. It has an area of about 10 square miles and surrounds the village of Coimadai, which lies 6 miles north of Bacchus Marsh, which, in its turn, is 32 miles W.N.W. of Melbourne.

The three parallel creeks, Djerriwarrh on the east, Pyrete or Coimadai in the centre, and Goodman's on the west are the main streams. Along the sides of their valleys, river terraces, generally two in number, may be observed. Several tributaries occupy hanging valleys, and perhaps the best example is one which joins the Djerriwarrh about a mile south of the Melton Road bridge. This

tributary flows east across the strike of the resistant sandstones of the Lower Ordovician series. The village of Comadai on the Pyrete Creek is situated in a basin which was probably formed while the creek was cutting a gorge for itself through the hard Ordovician sandstones in the extreme south of the area.

The important physiographic feature of the district is the Coimadai fault described by Hart and by Fenner[1]. It is a normal fault 5 to 6 miles long with a hade to the south. Its age is described as post-Older-Basaltic, but pre-Newer-Basaltic. Immediately to the west of the area it forms a boundary between Lower Ordovician rocks on the north and Permo-Carboniferous rocks on the south. Within the mapped area it probably changes its direction and swings to the north-east for a short distance with the outcrops of the Ordovician rocks and then dies out.

The eastern part of the area is a young plain in process of dissection. A prominent ridge exists between the Pyrete and Goodman's Creeks, and extends north and south beyond the limits of the area. It possesses a basalt capping which marks the course of the pre-basaltic river called the Bullengarook[2]. It is recorded that when the Bullengarook River was filled with basalt, the Pyrete and Goodman's Creeks arose, one on either side, and subsequently entrenched themselves in deep valleys.

Previous Work on the Area.

The oldest rocks of the area are the Lower Ordovician sediments. They belong to the Castlemaine horizon and have been described by Officer and Hogg[3] and by Harris and Crawford[4]. A glacial series of Permo-Carboniferous age rests on a glaciated surface of Lower Ordovician and it has been described by David[5], and by

1.—C. Fenner, "Physiography of the Werribee River Area," Proc. Roy. Soc. Vic., vol. xxxi. (n.s.), 1918, p. 236.
T. S. Hart, "The Highlands and Main Divide of Western Victoria," Proc. Roy. Soc. Vic., vol. xx. (n.s.), 1908, pp. 257-8.

2.—Fenner, op. cit., p. 248.
Harris and Crawford, "The Relationships of the Sedimentary Rocks of the Gisborne District," Proc. Roy. Soc. Vic., vol xxxiv. (n.s.), 1921, pp. 42-44.
A. W. Howitt, "Notes on the Geological Structure of North Gippsland," Geol. Surv. Vic. Prog. Rpt., No. 4, 1877, p. 117.
J. Stirling, "Notes on the Bullengarook Plateau," Geol. Surv. Vic. Prog. Rpt. (n.s.), Nos. 8 and 9, 1899, p. 49.

3.—G. Officer and Hogg, "The Geology of Coimadai, Part II.," with appendices by C. W. De Vis, and T. S. Hall on the Marsupial Bones of the Coimadai Limestone and the Graptolites of the District respectively, Proc. Roy. Soc. Vic., vol. x (n.s.), 1898, p. 180.

4.—Op. cit.

5.—T. W. E. David, "Evidences of Glacial Action in Australia in Permo-Carboniferous Time," Quart. Journn. Geol. Soc., vol. lii., 1896, pp. 296-8.

Officer, Hogg and Balfour[6]. "Wightman's Rock" and "The Twins" are two noted glaciated pavements within the area.

The relations of the Cainozoic rocks—the limestones, gravels, and basalt—have formed the main purpose of this paper. In regard to these Officer and Hogg record[7] that the limestone series is overlain by a series of sands, gravels, quartzites and conglomerates, the bed superimposed on the limestone being different in different places. The limestone is not considered to occupy an erosion valley in the associated beds for two reasons (a) the superposition of the overlying beds and (b) the absence of fragments of grit, quartzite or conglomerate in the limestone or intercalated gravels. Two and a half miles below Coimadai they record a reversed sequence, finding in descending order basalt, limestone containing Limnaea and Bulimus, and clay, sand, and conglomerates, which merge into a quartzite. They disagree with Ferguson[8], who considers that there is an unconformity between the limestone and Miocene strata, and state that the limestone is part and parcel of the beds with which it is associated. In a road cutting near the above section they note, in descending order, gravel and sand, pipe clay with *Laurus werribeensis* (130 feet below the limestone level), and gravel and sand. They infer that the Coimadai series lies above the Bacchus Marsh Leaf Beds, which contain *L. werribeensis*, and that there is a gradual passage from the pipe clays into the overlying beds.

Their conclusions are as follow[9]: The Coimadai series is a freshwater one, fluviatile and lacustrine. The postulated lake occurred on Lower Ordovician and Glacial strata and had a large indentation sheltered from the main flow of the river where special conditions gave still water. The limestone is a dolomitic travertine, chemically precipitated from carbon dioxide springs. The irregular and patchy distribution is due to the local and intermittent character of the springs. Contemporaneous volcanic activity gave carbon dioxide, but the springs continued long after its cessation. Intercalated bands of sand and angular quartz gravels indicate that freshets occurred in the streams entering the lake and the few isolated bones were probably brought down by streams. The hard quartzites were formed by siliceous springs. The sediments filled the Coimadai basin and spread east over the more or less flat country extending to the Djerriwarrh Creek.

The views of Officer and Hogg have been stated at some length as they present the results of the most detailed investigation of the area. A statement of the views of other workers is as follows.

6.—Officer and Hogg, op. cit., pp. 181-196; G. Officer, L. Balfour and E. Hogg, Aust. A.A.S., Brisbane, 1895, pp. 321-330.

7.—G. Officer and Hogg, "The Geology of Coimadai. Part I.," Proc. Roy. Soc. Vic., vol. x (n.s.), 1897, p. 65.

8.—W. H. Ferguson, "Notes on the Occurrence of Limestone at Merrimu," Geol. Surv. Vic. Prog. Rpt., No. 8, 1894, pp. 69-70.

9.—Op. cit., pt. i., pp. 68-70.

Dunn[10] says that the limestone forms an isolated hill. It occurs in thick beds with thin partings of shale, 1 to 2 inches thick containing abundant plant remains. He mentions that the beds dip in all directions, and puts their probable age down as Pliocene.

Brittlebank[11] says that a considerable period of time elapsed between the deposition of the Miocene and the flow of newer basalt as is shown by the depth of the old river channels. He draws attention to the absence of dykes of new basalt through the Miocene, contrary to his expectations.

Murray[12] advocates the view that the limestone is of Tertiary age and is either of freshwater origin or a spring deposit. It covers an area of 24 acres.

Description of the Kainozoic Rocks.

(*a*) *Limestone Series.*

Chemical Characters.—The Coimadai limestone is of commercial importance on account of its hydraulic properties and is worked at Alkemade's, Burnip's, and Hjorth's quarries. Its magnesian character is shown by the following three analyses:

	I.		II.		III.
SiO_2	0.55	–	0.69	–	2.33
Al_2O_3	nil	–	0.12	–	1.59
Fe_2O_3	2.07	–	1.55	–	15.91
MgO	20.37	–	19.17	–	15.96
CaO	29.74	–	31.30	–	24.46
CO_2	—	–	43.52	–	36.19
H_2O-	—	–	—	–	1.08
H_2O+	—	–	—	–	1.88
Ignition loss	46.39	–	—	–	—
	99.12	–	99.59	–	99.40
Moisture at 100° C.	0.32	–	0.31	–	—

I. Dolomite, Coimadai[13].

II. Limestone, Coimadai[14].

III. Dolomite, specimen No. 45, Hjorth's quarry, Coimadai, Analyst, A. L. Coulson.

10.—E. J. Dunn, "Notes on Some of the Geological Formations near Bacchus Marsh," Rep. and Stat. Min. Dept. Vic., for 1910, p. 26.

11.—C. C. Brittlebank, "Notes on So-Called Miocene Deposit of Bacchus Marsh," Vic. Nat., vol. xiii., No. 6, 1896, pp. 83-4.

12.—R. A. F. Murray, "Report on Limestone Quarries in the Bacchus Marsh District," Geol. Surv. Vic., Mon. Prog. Rpt. (n.s.), Nos. 8 and 9, 1899, p. 51.

13.—H. C. Jenkin, "Report of the Government Metallurgist for 1900," Ann. Rept. Sec. Mines, Vic., for 1900, p. 37.

14.—Op. cit., p. 38.

No. III. contains CaO, MgO, and CO_2 in practically the correct proportions for a dolomite. It is also a very ferruginous variety in comparison with the previously recorded analyses.

Officer and Hogg[15] record the following beds in descending order in Alkemade's quarry:

1. Gravel and ferruginous conglomerate, 8 feet.
2. Very fine blue clay, interspersed with finely laminated limestone shales with lenticular masses of hard limestone, 10 feet.
3. Yellowish limestone, soft, but containing bands of hard limestone, 6 feet.
4. Thin ash bed, 6 inches. This varies in thickness from 2 inches to a foot and has a wide distribution on both sides of the valley.
5. Yellowish white limestone, honey-combed in places, 6 feet.
6. Gravel and calcareous sand, 12 to 15 inches.
7. Calcareous sand, usually soft, containing mammalian bones, 3 feet.
8. Grit, sand, and gravel, calcareous, 1 foot 8 inches.
9. Soft earthy, gritty limestone, with lenticular masses of hard compact stone, 6 feet.
10. Hard compact limestone, very fine-grained in places, gritty in others, fawn, bluish, white, ? 26 feet.

The total thickness is thus about 70 feet. There is a considerable amount of distortion in the beds. Subsidence of the overlying clay beds follows the removal of any portion of the limestone bed. It is probable that the sagging down of the clay bands would keep pace with the solution of the limestone.

Microscopical Characters.- Many sections have been made of the limestones, particularly those of Alkemade's and Hjorth's quarries, and in all cases they are dolomitic

Specimens from Hjorth's quarry are light yellow in colour and prove to be exceedingly fine-grained under the microscope. The larger crystal grains resemble dolomite rhombohedra. Some specimens are comparatively free from iron, while others with a deeper colour contain both limonite and hematite, as in the analysed specimen, No. 45. In one case (No. 51) there are minute globules of iron oxide, concentrically arranged, and suggestive of xanthosiderite. In the same rock there is a suggestion of organic remains in certain curved bodies which are abundant. In a section through a concretion in the limestone the grains appear to be more scalenohedral than rhombohedral and are probably more calcitic than in the typical dolomitic limestone.

The most interesting specimens (Nos. 53, 70, 71) were obtained from a bed in Alkemade's quarry, 4 feet below the ash bed, in the north wall of the quarry. It is rather a peculiar type, being somewhat like a mudstone, though a little harder. It shows a laminated

15.—Officer and Hogg, op. cit., part i., pp. 62-4

character and is extremely fine grained. In places there are little lenticular shaped masses of calcite or dolomite, around which the laminae are curved, showing the lenticles to be of primary origin. With cold dilute acid there is a moderate effervescence and the test with Lemberg's solution shows the presence of calcite. The rock contains numerous grains, usually circular in shape, which vary in number in the different bands. The fact that some are not definitely circular in outline and are indented along the edges suggests their organic origin. Through the courtesy of Miss Cookson, of the Botany Department of the University, the grains in the sections were compared with pollen grains of various flowering plants, and in size and other particulars they agree in some respects with those of *Pinus*. The comparison would, however, have to be carried out on native Australian plants. The grains sometimes have a quadrate centre, while some seem to be composed of four segments. They always have an outer wall. In a section cut parallel to the bedding planes (No. 70) there is a suggestion of spines and wings very similar to pollen grains. Scattered through the section are a few grains of quartz and some chalcedonic silica.

A nodule of concretionary limestone occurring just above the lowest compact limestone of Alkemade's quarry is much harder than the usual dolomitic variety. It is brownish white in colour and contains small fragments of detrital quartz, shale and quartzite, which are set in a fine-grained groundmass, composed of minute scalenohedra of calcite. In another example of dolomitic limestone the majority of the grains are dolomitic rhombohedra, from which the central core seems to have been removed. Some of these are more circular than rhombohedral, and suggest organic remains, but are too minute to be diatoms. In a further variation of the limestone, limonite occurs as pseudomorphs after pyrite, while in one instance the individual crystal grains are of the nature of zoned rhombohedra with curved faces.

Ochres.—Pocket-shaped masses of "ochres" are found in the limestone in the three quarries and vary in colour from red to yellow. A sample of impure red ochre was obtained from the south-east corner of Alkemade's quarry, where it forms small lenticular shaped masses. The material is extremely soft and porous and, when examined under the high power, it is seen to consist of minute rhombs of dolomite, with an outer edge of limonite or hematite embedded in fine-grained calcite. The iron is probably derived from the decomposition of siderite and the varying stages in the alteration of the siderite to limonite or hematite correspond with the changes in colour from a yellow to a deep red. The ochre is essentially a carbonate, as with cold dilute hydrochloric acid, the average loss, after standing for an hour, was 88.6%.

A sample of "yellow ochre" from the east wall of Hjorth's quarry is finer grained than the preceding, and more dolomitic. Its colour is due to numerous globular grains of limonite, while there are a few rectangular crystals of hematite, possibly pseudomorphs after pyrite.

Ash Bed.—The ash bed, which occurs in the three quarries, is a valuable bench mark. Its origin has been confirmed by the microscopical examination. It is a yellowish coloured rock which is extremely friable in Hjorth's and Burnip's quarries, but considerably harder in Alkemade's. Under the microscope, quartz is the most abundant mineral present. Biotite and felspar occur together in fragments, but the nature of the latter is indeterminate. Radiating aggregations of an unidentified colourless mineral with straight extinction, high refractive index, and low polarisation colours can be seen. Picotite, monazite, with high polarisation colours, and pyrite occur occasionally. Numerous pieces of slate, shale, sandstone, etc., can be identified.

In the harder rock (No. 54) from Alkemade's quarry, the quartz grains nearly all show irregular cracks and a rounded outline. Twinned crystals of plagioclase are recognised in the igneous fragments, but picotite is less frequent. A minute cellular structure is also observed which confirms its volcanic origin. It seems likely that the deposition of ash fragments and of sediment has occurred from simultaneous processes.

(*b.*) *Upper Cainozoic Gravels, Sands, etc.*

These cover a large part of the area and are variable in nature. In places the gravels are cemented by silica giving quartzites, grits, etc., and in others by ferruginous matter giving ferruginous grits, etc. Sometimes a calcareous cement is present. The lowest gravels are extremely coarse, containing large blocks of the ancient bedrock and resemble torrential river deposits. The ironstones yield a large amount of buckshot gravel and occur at a higher level than the coarse deposits, forming the flat country on the eastern side of the area near the Djerriwarrh Creek.

The ironstones are variable and an example from allotment 11a, Merrimu, is a fairly hard reddish type. It consists of angular and rounded grains of quartz in a matrix of limonite and hematite, together with a few small flakes of muscovite .

The ferruginous sands from allotment 9B, Merrimu, show gradations from a dark red ironstone to a white quartzite. A dark variety consists of rounded quartz grains and occasional flakes of muscovite, cemented by ferruginous matter from percolating solutions. The general appearance of the quartz grains is rounded, but evidence of attack is observed under the high power, and the margins are corroded. The iron oxide appears sometimes as minute globules which may be xanthosiderite. In a quartzite from the same locality the cement is silica. As in the ferruginous sands, the grains are corroded along the edges, while some have been recrystallised to a polysynthetic mosaic.

In a soft sandstone occurring immediately under the basalt in allotment 4B, Coimadai, occasional muscovite, light green tourmaline and zircon are observed in addition to the quartz. In another

sandstone under the basalt at the corner of Coimadai and Bullengarook roads, a considerable amount of kaolin indicates a felspathic type. Below this sandstone are ironstained sands which pass into very fine incoherent sands with beds of intercalated pipe clay. The sands are used commercially. Occasional small crystals of tourmaline and zircon are detected under the microscope and it is probable that the deposits are lacustrine.

(*c*) *Monchiquite Dykes.*

Monchiquite dykes are exposed along the bed of Goodman's Creek where they are intrusive into Permo-Carboniferous beds. They do not come into contact with the basalt or the gravels, but are likely to be of the same age as the monchiquite dykes of Daylesford which appear to be pre-Newer-Basaltic. A group of six occur about ¾ miles south of the junction of Back and Goodman's Creeks. A little north of this group are two more, one of which is very decomposed. The other, being relatively fresh, was sectioned. It is 18 inches wide and trends N. 88° E.

The hand specimen is dark and heavy and shows numerous phenocrysts of olivine. Under the micrcoscope olivine and augite occur as phenocrysts, the former being extensively altered to serpentine. Black grains of ilmenite, rectangular prisms of a titaniferous augite, together with a brown glass, form the groundmass of the rock. Secondary calcite is common and felspar is absent.

(*d*) *Basalt.*

The source of the basalt is probably Mount Bullengarook. North of the area it has been estimated to be 250ft. thick and 300ft. wide, but it narrows to 40ft. wide and 3ft. thick at a place known as "The Neck." Southwards from this, it widens and increases in thickness to about 40ft. Its nature[16] is usually that of an olivine basalt though magma basalt and limburgite occur, the latter towards the north. The minerals present are labradorite, augite, secondary calcite, magnetite and a light brown glass.

At the junction of Coimadai and Bullengarook roads angular fragments of sandstone are embedded in the basalt. The junction of the basalt and the inclusions is marked by an irregular line of minute pyroxene crystals. In a few places in one example (No. 41) the pyroxene crystals are arranged at right angles to it. Many minute crystals of ilmenite are interspersed along the reaction rim and the quartz of the sandstone is corroded and penetrated by the pyroxene crystals. A dark red mica, occurring in small flakes, has been developed in the sandstone, and olivine has been entirely altered to iddingsite.

16.—Officer and Hogg, op. cit., pp. 70-4.

General Discussion of the Problem of the Limestones, Gravels and Basalt.

Age of the Limestone.—The fossils described from the limestone series by De Vis[17] are:

Phascolomyidae: *Phascolomys parvus*, (Owen).

Macropodidae: *Macropus (Halmaturus) dryas*, (De Vis). *M. anak*, (Owen). *M. cooperi*, (Owen).

Nototheriidae: Several bones not referred to any definite genus.

The vegetable fossil remains consist of fragmentary grasses and characeous plants. These fossils, both animals and plants, are all referable to the Pleistocene, in which series, chiefly in Queensland, similar fossils have been found. A Pleistocene age is therefore assigned to the limestone series, which has been variously referred to as Lower Tertiary[18], Miocene[19], and Pliocene[20].

Formation of the Limestone Basin.—The occurrence of the Coimadai fault had a very profound effect on the drainage system of the area. The pre-Newer-Basaltic stream known as the Bullengarook River, was rejuvenated by it, and a direct result was the deposition of a mass of very coarse torrential material and the formation of the lowest gravels over the relatively sunken area to the south. Later the river gradually regraded itself by headward erosion from the fault scarp, and fan deltas came into existence and finer material was deposited.

Eventually the Bullengarook River filled up the area south of the fault scarp with a mass of incoherent gravels, through which it carved for itself a broad open valley. The uneven surface of this material was possibly accentuated by further movements along the fault plane. It may be supposed that with the collection of water in the irregularities of the surface a quiet lake developed, with little or no sediment from the main river, which had reached a state of old age in Pleistocene times. The development of the lake was possibly assisted by the damming of the river, in its southern part, by one of the earlier flows of newer basalt.

Development of the Limestone and Gravels.—The series under consideration is purely a local one and there are no known older dolomitic rocks in he neighborhood. It is clearly, therefore, not an example of the clastic method of dolomitic formation.

The uniform extreme fineness of grain in all examined specimens and the absence, with one or two possible exceptions, of calcareous organisms, suggest its derivation as a chemical precipitate. In addition, however, there has been, as in No. 58, solution of the

17.—Officer and Hogg, op. cit., pt. ii., pp. 198-201. C. W. De Vis, "Review of the Fossil Jaws of the Macropodidæ in the Queensland Museum." Proc. Lin. Soc., N.S.W., vol. x., 1895, pp. 75-133. R. Owen, "Researches in the Fossil Remains of the Extinct Mammals of Australia," 1877, Erxleben.

18.—Ferguson, op. cit., p. 70.

19.—Officer and Hogg., op. cit., pt. i., pp. 66, 67.

20.—Dunn, op. cit., pp. 26, 27.

central core of the zoned rhombohedra. This suggests that the central core was different chemically (probably calcite) to the outer rim and that, subsequent to its precipitation, there has been differential leaching of a slightly magnesian limestone. It is therefore, likely that the Coimadai dolomitic limestone is the result of two processes, viz., the deposition of a chemical precipitate of magnesian limestone, and the differential leaching, in places, of this precipitate giving a more magnesian limestone.

The formation of the "ochres" involves secondary alteration of the limestone, for an outer zone of siderite in rhombic sections is altered to limonite and hematite.

The chemical precipitate and the development of quartzites and ironstones, etc., from the incoherent gravels may be accounted for by springs containing calcium, magnesium and iron salts, and also carbon dioxide and silica, in solution. This is in general agreement with the views of Officer and Hogg. As these springs entered the quiet lake, a condition of saturation would quickly develop, if the amount of water lost by evaporation exceeded that flowing into the basin. Further evaporation would cause the deposition from solution of the carbonates of lime and magnesia, while local concentrations of iron oxide and iron salts might be expected. The precipitated matter should, therefore, roughly correspond to the shape of the basin, accounting for the observation that all the limestone beds dip centrally.

When the spring waters percolate through the gravels their resultant effects are great, but naturally very sporadic and variable.

As the normal state of quiescence in the lake became disturbed by flood waters, small amounts of sand and gravel were intercalated among the limestone beds. The few mammalian bones, which are confined to these sandy beds, were transported in this manner, and with a reversion to the quiet conditions, the precipitation of the limestone would continue. Very quiet conditions are indicated by the preservation of the delicate casts of pollen grains showing the structures of spines and wings.

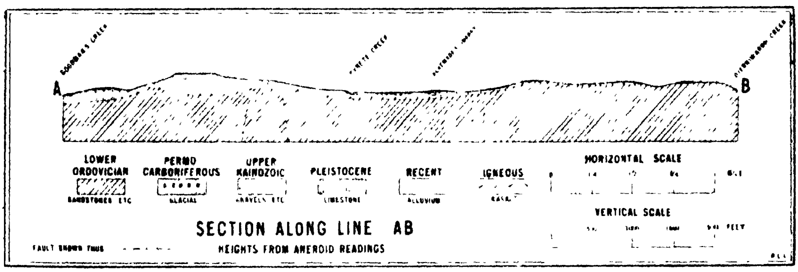
Basaltic lava flows followed the sedimentation in the lake, but were preceded by the outburst of a fine ash, which has only been preserved in the limestone lake. Officer and Hogg do not connect the ash bed of the quarries with the outflowing of the basalt, but it seems a logical correlation as Brittlebank[21] has noted an ash band in the Parwan Creek basalts, not very far distant. Assuming a relation between the two, the limestone must be geologically younger than part of the basalts, which can then be placed as Pleistocene. In this case the lava flow from Mt. Bullengarook filled the valley of the old Bullengarook River without affecting the limestone lake where the deposition from solution continued. The basalt is quite similar to the newer basalts of the Western

21.—C. C. Brittlebank, op. cit., p. 84.

district and the Melbourne area, whose age is considered by Professor Skeats to vary from the Pliocene to recent[22].

The outpouring of basalt completely altered the drainage system of the area. Pyrete and Goodman's Creeks came into existence and deposited, in their initial stages, high level gravels as a capping over the older rocks. In deepening their channels they carried away much of the soft gravel deposit of the old Bullengarook River, destroyed the limestone lake and removed most of the limestone. The whole of the limestone deposit was not destroyed and the remnant is now covered by the higher level gravels of these streams.

The beds of Hjorth's quarry dip north into the valley at a slightly greater angle than the slope of the surface gravels, which are here five or six feet thick. Precisely the same occurs at Alkemade's and Burnip's quarries, the beds dipping south in the latter case. In consequence Ferguson[23] infers a strong unconformity between the "Miocene" strata and the limestone series, while, according to the above theory, the surface gravels are considered to be the debris or hill wash of the higher level gravels of the Pyrete Creek.



In the above hypothesis the gravels are not regarded of one age, but range from Miocene to Recent. They are mapped as Miocene by the Geological Survey of Victoria[24]. Howitt[25] and Ferguson[26] place them as Miocene, while Officer and Hogg state that the Miocene gravels, to the south of the area, grade up into the sands and gravels in question and they map the latter as Miocene.

In the accompanying map (Plate XII.) there are several minor alterations of the geological boundaries, compared with the earlier maps. The roads and allotment boundaries are taken from the parish plans of Coimadai and Merrimu. The chief point of divergence between this map and the unpublished quarter-sheet of the

22.—E. W. Skeats, "The Volcanic Rocks of Victoria," Pres. Add., Sec. C, Aust., A.A.S., Brisbane, 1909, p. 209.

23.—Op. cit., p. 69.

24.—Quarter sheet No. 12, N.E. (unpublished).

25.—Op. cit.

26.—Op. cit., pp. 69-70.

Geological Survey, a copy of which was obtained through the courtesy of Mr. D. J. Mahony, M.Sc., and Mr. W. E. Bennett, is in the boundary of the Upper Kainozoic gravels with the Lower Ordovician near the Coimadai Road, running E.S.E., from its junction with the Bullengarook Road, to the Pyrete Creek. The chief difference from Officer and Hogg's boundaries of the Ordovician and the Upper Kainozoic gravels occur in the north west corner, near Goodman's Creek, and in the north central area north east of Burnip's quarry. The mapping of the eastern part of the area along Djerriwarrh Creek is new. The fault marked on the map is the approximate position of the Coimadai fault.

Summary and Acknowledgments.

The area surrounding the village of Coimadai has been remapped and the relations of the Tertiary series have been studied. Many sections of the limestones and gravels have been examined microscopically and one specimen analysed. A laminated limestone containing fossil pollen has been described and the occurrence of an ash bed has been confirmed.

The earliest of the gravels are probably of Miocene age. Previous workers have placed the age of the Comadai fault as pre-Newer-Basaltic and post-Older-Basaltic, and have claimed that the Miocene gravels south of the area pass up into the sub-basaltic series. Owing to the impossibility of distinction between the various gravels in the field, they are classed as Upper Kainozoic in the accompanying map, this term signifying a range from Miocene to post-Pleistocene.

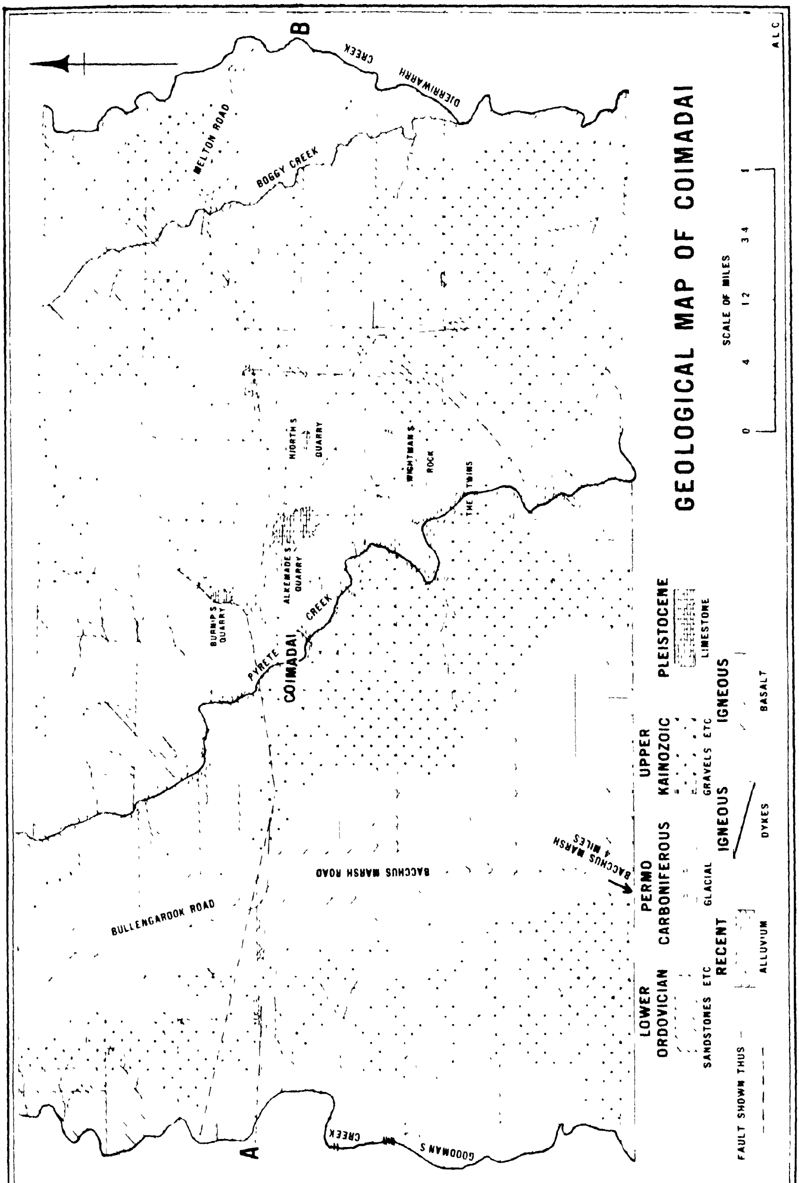
The limestone series is placed as Pleistocene. Its deposition occurred at the same time as the formation of the quartzites, conglomerates, ironstones, etc., in the adjacent gravels. The sub-basaltic sands and limestone are placed on the same horizon as the quarry limestones. Later than these are the sands and gravels of the Djerriwarrh Creek area.

The limestone is considered to have been chemically precipitated just before, during, and after the Bullengarook lava outburst, in a small local basin which probably owed its origin to unequal consolidation of the gravels.

In conclusion the writer wishes to record his most grateful thanks, to the following: Professor E. W. Skeats, for much assistance in the nature of criticism and advice throughout the course of the work; Associate-Professor H. S. Summers, for many helpful suggestions and discussions; and Mr. F. Chapman, for pointing out the presence of pollen grains in the limestones.

EXPLANATION OF PLATE.

Plate XII.—Geological Sketch Map of Coimadai.


GEOLOGICAL MAP OF COIMADAI
SCALE OF MILES
LOWER ORDOVICIAN
SANDSTONES ETC
RECENT
ALLUVIUM
PERMO CARBONIFEROUS
GLACIAL
IGNEOUS
DYKES
UPPER KAINOZOIC
GRAVELS ETC
IGNEOUS
BASALT
PLEISTOCENE
LIMESTONE
FAULT SHOWN THUS
DJERRIWARRH CREEK
MELTON ROAD
BOGGY CREEK
HJORTHS QUARRY
WIGHTMAN'S ROCK
THE TWINS
ALKEMADE'S QUARRY
BURNIPS QUARRY
PYRETE CREEK
COIMADAI
BACCHUS MARSH ROAD
BACCHUS MARSH 4 MILES
BULLENGAROOK ROAD
GOODMAN'S CREEK
A
B
A L C

[PROC. ROY. SOC. VICTORIA, 36 (N.S.), PT. II., 1924.]

ART. XI.—*Studies on the Transpiration of some Australian Plants, with Notes on the Structure of their Leaves.*

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(With Plates XIII.-XVIII., and Text Figs. 1-7.)

[Read 13th December, 1923.]

This work was commenced at the beginning of 1920 on the suggestion of Professor A. J. Ewart, and was made possible through the kindness of Professor J. Smyth in allowing me the time to prepare for, and carry out, the experiments in 1920.

So little work has been done on the transpiration of Australian plants, that I was glad to have the opportunity of attacking a branch of research work which opened up so many possibilities.

Moore, p. 207 (29) in 1899 wrote: "But we are told that the Australian flora stands less high in the scale and is less specialised than are the floras of northern climates; and, if this be true, the point I am trying to argue must at once be given up. But is it true? In what respect, it may be asked, is the flora of Australia less highly specialised. Are not most of the great natural orders strong constituents of it? Trees, some of them of gigantic size, shrubs, undershrubs, and herbs, parasites and saprophytes, climbing and carnivorous, flowers adapted to profit by the visits of insects, and sometimes provided with a complex mechanism to ensure such profit—all these are met with in Australia. In addition, we have wonderful adaptation to a dry climate, and in this respect, taking into account the variety of ways in which the destructive effects of a scorching sun and parched soil are guarded against, the Australian flora is without parallel the world over."

Ewart and Rees, p. 85 (15), wrote: "In at least one respect the Australian conditions as represented in the Melbourne district are comparatively unique, for, at certain times, hot dry winds blow from the interior and cause rapid rises of temperature up to 100° or even 120° F. The hot spell rarely lasts long and is usually followed by a cool change often accompanied by rain. The fall of temperature is usually more rapid than the rise. . . In neither case does the suddenness of the change appear to operate injuriously upon the vegetation, while its rapidity and irregular occurrence would be sufficient to prevent slowly responding plants specially adapting themselves to it. . . . . . ."

Many other biologists have written in similar strain, and the outlook promised some surprises. My main object was to discover whether Australian plants have any special powers of accommod-

ating themselves to adverse conditions, especially of regulating the transpiration rate when the temperature suddenly increases; hence, I considered it would be advisable to work with as many plants as I could handle, and to concentrate on the transpiration rates rather than to work with a few plants and deal more fully with their anatomy.

The work may be classified under the following heads:

(1) Preparation of laboratory.
(2) Preparation of plants and material.
(3) Estimation of transpiring areas.
(4) Estimation of the number of stomata per unit area, their distribution and measurement.
(5) Meteorological data.
(6) Illustrations: Photographs and micro-photographs.
(7) Transpiration experiments.
(8) Plants studied.
(9) Discussion on transpiration and the results of the experiments.
(10) Conclusions.

(1) Preparation of Laboratory.

As there was no room in or close to the Botany School where a large number of experiments could be carried on simultaneously, it was necessary to go further afield. Finally, it was decided to use the building in the system garden in the north-west corner of the University Grounds. The building consisted of a tower built of brick, with a glass house adjoining. The room in the tower was renovated and fitted with cupboards. The wide open space in front of the tower was admirably suited for outdoor experiments. In another part of the garden, a wire-netted enclosure had been constructed to protect experimental plots of cereals from birds, and this was used to prevent the plants from being interfered with. Meteorological instruments were housed in a properly constructed shed, which had been used by members of the Natural Philosophy School when making observations on the wet bulb thermometer.

I wish to thank Professor Laby for allowing me to transfer the building to the system garden and to use it in connection with the transpiration experiments. I fitted the shed with a rack and shelves so that it could be used for transpiration experiments on wet days and for observations in the shade. Arrangements were also made to accommodate the plants in the glass house if necessary.

(2) Preparation of Plants and Material.

At first I attempted to obtain a supply of plants by transplanting them from the bush, but without success. I then visited the Botanic Gardens, and explained my requirements to the Director, the late Mr. J. C. Cronin, and I have to thank him for a fine supply of plants and for the interest both he and his staff took in the

work for which I was preparing. I also visited the Burnley Horticultural Gardens and received a kindly welcome from the late Mr. J. P. McLennan and his staff. All were keenly interested in the experiments and supplied me with any plants they had on hand. The specimens of *Ficus macrophylla* were obtained from the University garden and a number of seedlings of *Banksia serrata* were sent to me from Sale by my friend, Mr. H. J. Hauschildt, of the Sale Agricultural High School. In all, I collected one hundred plants. Of course, many of these were in duplicate. All plants were repotted into pots of three sizes (6 inch, 5 inch, and 4 inch) according to the type of plant, and what was considered would be its future requirements, especially in relation to the amount of water required during the transpiration experiments. The register number of the plant was written on the side of the pot with Brunswick black, and a label, with the same number, was attached to the plant.

I was unable to use two or three which were attacked by disease, and one or two which were broken by accident; but the rest thrived, and I had quite sufficient for my purpose; the number that I could use being limited by the number that could be weighed in a certain time. While the experiments were in progress, the plants were kept in the tower or in the glass house, but were transferred back to the open when not required. They were allowed to grow under conditions as normal as possible.

(3) Estimation of Transpiring Areas.

The method adopted in most cases was that of making a tracing of each leaf, either by placing the leaf on a sheet of white paper and drawing in the outline with a fine pencil, or of placing the leaf on a board, covering it with transparent paper and tracing the outline on the paper. The latter method was used with the leaves of *Grevillea robusta*. Areas were then found by means of Amsler's Polar Planimeter.

The foliage of numbers 13, 17, 19, 27, 34, 75, and 81 did not lend themselves to these methods; each required a special method which is described later.

I am much indebted to Professor Payne and Associate Professor Kernot, of the Engineering School, for assistance in obtaining specimens and for the use of apparatus.

(4) Estimation of the Number of Stomata per Unit Area, their Distribution and Measurement.

Removal of epidermis.—To enable counting to be done accurately, it was necessary to remove the whole of the epidermis intact. A number of methods for removing the epidermis was tried and finally the following was adopted: A fresh, green leaf was taken and, after cutting a thin slice off one margin, it was placed in a 15% solution of nitric acid in water, and boiled in a beaker until it could be seen that the epidermis was almost free from the tissues beneath.

It was necessary to watch the process the whole time and to manipulate the leaves with a glass rod to prevent them from adhering to the sides of the beaker. At first, the epidermis appeared to form the surfaces of blisters, but later, the epidermis of the upper and under surfaces would separate along the cut margin and open outwards.

The epidermis of the branchlets of *Casuarina Luehmanni*, of *Acacia iuniperina*, and of the leaves of *Hakea gibbosa*, was removed by first making a slit along the whole length of the structure with a razor—along the ridge in *C. Luehmanni*, and between ridges in *A. juniperina*, and then treating in the acid solution as described above.

Much was learnt in this way about the relative strengths and thicknesses of the epidermis of both surfaces of the leaves; and how greatly the epidermis differs in different families and in species. A phyllode of *Acacia longifolia* was boiled for 30 minutes in a 25% solution of nitric acid and the epidermis was then still almost as tough as leather. The epidermis of the leaf of the adult *Eucalyptus alpina* was the most difficult to remove, while that of the seedling leaf of *E. maculata* var. *citriodora* required very careful handling as the epidermis of both sides is very thin. No definite time for boiling each type of leaf in the solution can be laid down; it is a matter for observation and judgment for each leaf. Leaves of adult Eucalypts and Acacias require from 10 to 15 minutes to clear the epidermis; while the leaves of *Prostanthera lasiantha* or *Oxylobium lineare* do not require a minute.

The material was then removed from the boiling solution, well washed with water and left for a day or two in a large amount of water.

The soft, disintegrated tissue was then easily removed from the epidermis by means of a forceps; and the inner surface of the epidermis cleared entirely by gently rubbing it under water with a seeker, a small swab of wadding or a camel's-hair brush.

Staining.—A water solution of gentian-violet gave good results and was used generally. The Acacias gave the best results with it, as, apparently, the tannic acid in the epidermis acted as a mordant and fixed the stain. They required only two or three minutes to stain, and, if left much longer, were overstained. The members of the Myrtaceae took much longer to stain than the Acacias, and did not stain so well The guard cells of the stomata usually stained very darkly.

After being stained, the material was placed in water until it could be examined, usually for not longer than two days.

Counting.—As the epidermis of both surfaces had been severed along one margin, they could be separated, opened out and placed side by side for examination. For the larger leaves a 3in. by 2in. glass slide, with cover-slip, was used. Long structures, like the phyllodia of *Acacia saligna*, were cut into large sections for examination.

The arrangement and massing of stomata could easily and quickly be examined over the whole surface with a low power objective. All the stomata on a leaf were not counted, but a large number of readings were made and the average taken. It was found that the best average was obtained by taking a series of readings midway between the midrib and the margin from apex to base. The number of stomata tends to increase from the margins to the midrib in the majority of cases. To assist in counting, grids, with different numbers of divisions, were introduced into the eyepiece as required. A microscope with No. 2 ocular and No. 7 objective was used in counting the stomata.

Measurements.—All measurements of stomata are given in micra. As all leaves were treated in the same way to remove the epidermis, very little variation was found in the condition of the pores, which were usually almost closed. Hence, it was considered advisable to measure only the length and breadth of the stomata outside the guard cells. The stomata were measured with a Leitz micrometer eyepiece and stage micrometer.

(5) Meteorological Data.

Temperature records were obtained by means of a thermograph which was housed in the meteorological shed, but, when only transpiration balance experiments were in progress, in the tower.

For all other meteorological data I am indebted to Mr. H. A. Hunt, Commonwealth Meteorologist, and his staff, who have always been ready and willing to assist me by supplying any information in their possession.

All meteorological data will be found set out in Tables II. and III., on pages 185 and 186 respectively.

(6) Illustrations.

Photography.— Having so many plants to deal with, photography was made use of at all stages to illustrate types, growth, structures, and apparatus.

Microphotographs of all stomata and of a few sections of leaves will be found on Plates XIV. to XVIII., in the order of, and under the register numbers of the plants to which they belong. Most of the microphotographs of stomata were taken with a magnification of 110 diameters, so that their sizes might be compared. On the figures in the plates where the magnification is not indicated, it should be taken as 110 diameters. In reproduction the originals have been reduced 50 per cent.

I owe a debt of gratitude to Professor Woodruff and to Dr. Seddon, of the Veterinary School, for allowing me to use the microphotographic apparatus, and for placing the room and materials at that school at my disposal, and to my brother, Mr. J. I. Wilson, for his help in making prints as required.

(7) Transpiration Experiments.

Two methods were used to obtain the records:

(1) The Transpiration Balance. Plate XIII., fig. 1.

(2) Direct weighing.

Most of the work was done by the second method, as the Transpiration Balance cannot be used in the open air, and only one plant at a time can be dealt with. As no apparatus, such as mentioned by Ganong, p. 45 (18), for preventing evaporation, was available, it was necessary to improvise a method; so, for the purpose, a number of empty cylindrical tins, 6in., 5in., and 4in. in diameter, were procured. When a pot was placed in a tin, the flange rested on the upper edge of the tin and the surface was sealed by means of one tin disc and two rubber cloth discs held in position by a strong rubber band. Plate XIII., fig. 1. With practice, the plants could be prepared for weighing at the rate of one per minute.

As the idea was to work with as any plants as possible, and, as it was desired to compare their activities under similar conditions, it was necessary to arrange for weighing all of them quickly. For this purpose, the plants were divided into three series according to the size of the pots. A fourth series was used in February, 1922, and experiments on evaporation from the free surface of water were done in conjunction with it. The series were arranged as follow:

Series A.—Plants Nos. 1 (3), **6**, 13, 14, 19, 27 (28), 33, 49, 59, 63, 67, 71, 81, **86**, **88**.

Series B.—Plants Nos. 26, 31, 34 (35), **40 (41)**, 50, 52 (53), 64, 68, 69, 78, (79), 83, 87.

Series C.—Plants Nos. (16) 17, 22, 29, 42 (43), 44 (45), 47, 53, 62, 66, 75.

Series D.—Plants Nos. 1, 14, 49, 82.

The number in brackets denotes a duplicate which was used at some time during the course of the experiments. Both in tables of records of weighings (Tables IV. to X.) and in the graphs to illustrate them (Figs. 1 to 7), the plants were kept in these series, except in the graphs, when Nos. 6, 86, and 88, of Series A were transferred to Series C, as the lines were too crowded in Series A; and No. 41 was transferred from Series B to Series C.

During the winter, this method of preventing evaporation from the pots was tested with dummies, both on the Transpiration Balance, and by direct weighing, and the loss by evaporation was negligible.

During the summer months similar experiments were also made, and it was found that there was a slight loss, which varied from hour to hour, the average loss per hour being from .2 to .5 gramme per pot.

On account of this, there will be a tendency for the transpiration results to vary slightly from the normal rate. All the weighings were carried out in the tower, and the plants, after being weighed, were placed outside on a low bench when the weather was

fine, or in the meteorological shed on wet days, and for shade experiments.

All records with the Transpiration Balance were obtained in the tower. All calculations, as far as possible, were made with the slide-rule or with a calculating machine, for the use of which, I was indebted to the kindness of Professor Berry.

The transpiration experiments fall into four groups as regards time:

(a) July and August, 1920. (Winter.)
(b) December and January, 1920-1921. (Summer.)
(c) February, 1921.
(d) February, 1922.

A large number of weighings were made in July and August, to estimate the transpiration during the day in the shade, and at night. The weighings were made after periods of 3 to 6 hours.

The earlier weighings in the summer were made at intervals of from 3 to 6 hours in daylight; but, on special days, as many weighings as possible were made at hourly periods.

For purposes of comparison efforts were made to do weighings on consecutive days, and, as it happened, the results were unusual. For instance, on 23/12/20, the temperature rose to 108° F. at 2 p.m., and there was a pleasant breeze blowing from the east. On 24/12/20, the temperature rose as high as on the previous day, reached its maximum a little later, but there was a fierce north wind blowing for most of the day. It started some time before dawn and had reached 30 m.p.h. at 9 a.m., and gradually decreased towards sunset. (Table III., p. 186). Otherwise, conditions were practically the same for the two days. On 30/12/20 and 31/12/20, the conditions so far as the wind was concerned were reversed; but the temperature rose slightly higher on the second day. On 10/2/21 and 11/2/21, wind and temperature conditions were much the same, except that the temperature on the 11th lagged behind that of the 10th at 9 a.m. The plants were watered on the night of 9/2/21, but not again until the night of the 11th. The idea was to test for the wilting of the plants from insufficient supply of water, if possible.

As so many different types of plants were used, and their areas differed greatly, **all weight records have been standardized, the standard being the "number of grammes of water transpired per sq. metre per hour."**

(8) Plants Studied.

The following table gives a list of the plants which were used in the experiments. **Each plant was allotted a register number and this number is used throughout, in preference to repeating the name, in the text, in tables, and in illustrations.**

Twelve orders are represented by 32 species, and of these more than half belong to families found only in Australia, (Maiden, p. 163 (26)), and some of them are typical of special localities only, e.g., Nos. 67, 68, 13, etc.

INDEX TO PLANTS USED IN EXPERIMENTS.

Reg. No.	Name of Plant.	Date of planting.	Size of pot, in inches.	Gardens obtained from.
	Pittosporaceae			
1	*Pittosporum undulatum*	Aug., 1918	6	Botanic
3	,, *undulatum*	,, 1918	6	Burnley
	Sterculiaceae			
6	*Brachychiton populneum*	Aug., 1917	6	Burnley
	Casuarinaceae			
13	*Casuarina Luehmanni*	Aug., 1918	6	Botanic
	Urticaceae			
14	*Ficus macrophylla*	Aug., 1917	6	University
	Leguminosae			
16	*Acacia juniperina*	Aug., 1919	4	Botanic
17	,, *juniperina*	,, 1919	4	,,
19	,, *linearis*	,, 1918	6	,,
22	,, *montana*	,, 1919	4	Burnley
26	,, *pycnantha*	,, 1919	5	Botanic
27	,, *longifolia*	,, 1918	6	,,
28	,, *longifolia*	,, 1918	8	Botanic
29	,, *longfolia*	,, 1919	4	Burnley
31	,, *podalyrafolia*	,, 1919	5	Botanic
33	,, *saligna*	,, 1919	6	,,
34	,, *Baileyana*	,, 1918	6	,,
35	,, *Baileyana*	,, 1919	5	,,
40	*Oxylobium ellipticum*	,, 1918	5	,,
41	,, *ellipticum*	,, 1918	5	,,
42	,, *lineare*	,, 1918	4	,,
43	,, *lineare*	,, 1918	4	,,
44	*Pultenaea daphnoides*	,, 1918	4	,,
45	,, *daphnoides*	,, 1918	4	,,
	Thymeleaceae			
47	*Pimelea flava*	,, 1919	4	,,
	Myrtaceae			
49	*Eugenia Smithii*	Aug., 1918	6	Botanic
50	,, *myrtifolia*	,, 1918	5	Burnley
52	*Eucalyptus macrorrhyncha*	,, 1919	5	Botanic
53	,, *macrorrhyncha*	,, 1919	4	,,
59	,, *botryoides*	April, 1918	6	,,
62	,, *botryoides*	Aug., 1919	4	,,
63	,, *globulus*	,, 1918	6	Burnley
64	,, *globulus*	,, 1919	5	,,
66	,, *globulus*	,, 1919	4	,,
67	,, *alpina*	,, 1917	6	Botanic
68	,, *alpina*	,, 1919	5	,,

Reg. No.	Name of Plant.	Date of planting.	Size of pot, in inches.	Gardens obtained from.
69	,, *cladocalyx*	,, 1919	5	Burnley
71	,, *citriodora*	,, 1918	6	,,
75	*Leptospermum lanigerum*	,, 1919	4	Botanic
	Proteaceae			
78	*Grevillea robusta*	Aug., 1919	5	Burnley
79	,, *robusta*	,, 1919	4	,,
81	*Hakea gibbosa*	,, 1918	6	Botanic
82	*Banksia serrata*	,, 1919	4	Sale (in bush)
	Rubiaceae			
83	*Coprosma Baueri*	Aug., 1918	5	Burnley
	Labiatae			
86	*Prostanthera lasiantha*	Aug., 1918	6	Burnley
	Scrophulariaceae			
87	*Veronica Dieffenbachii*	Aug., 1918	5	Burnley
	Myoporaceae			
88	*Myoporum insulare*	Aug., 1918	6	Burnley

TABLE I.—AREAS OF FOLIAGE OF PLANTS USED IN EXPERIMENTS.

A.—Total area of foliage and stems or phyllodia in square cms.
B.—Total area with stomata—transpiring surface in square cms.

	WINTER READINGS.				SUMMER READINGS.				
Reg No	Date.	A	B		Date.	B		Date.	B
1	29/7/20	267	267	-	24/12/20	356	-	6/1/21	338
1				-			-	4/2/22	596
3				-	29/12/20	324	-		
3				-	5/1/21	281	-	17/2/21	281
6	16/8/20	92	92	-	5/1/21	244	-	17/2/21	339
13	10/8/20	621	260	-	6/1/21	330	-	17/2/21	330
14	30/7/20	321	321	-	29/12/20	440	-		
14				-	6/1/21	423	-	17/2/21	462
14				-			-	4/2/22	656
17	11/8/20	329	329	-	6/1/21	1802	-	10/2/21	1538
19	26/7/20	336	672	-	29/12/20	956	-		
22	3/8/20	34	68	-	6/1/21	552	-	17/2/21	552
26	27/7/20	107	214	-	29/12/20	1031	-	17/2/21	880
27	23/7/20	903	1806	-	28/12/20	6646	-	17/2/21	5508
28				-	28/12/20	4515	-		
29	3/8/20	36	72	-	6/1/21	560	-	17/2/21	530
31	27/7/20	92	184	-	29/12/20	766	-		
33	27/7/20	154	308	-	10/1/21	1368	-	17/2/21	532
34				-			-	6/1/21	2042
35	11/8/20	192	384	-	29/12/20	580	-		
40	2/8/20	150	150	-	5/1/21	1291	-		
41				-	5/1/21	630	-		
42	3/8/20	40	80	-			-		
43				-	6/1/21	420	-		
44	2/8/20	61	61	-	6/1/21	71	-		
47	30/7/20	27	27	-	28/12/20	136	-		
49	30/7/20	282	282	-	29/12/20	530	-	17/2/21	530
49				-			-	4/2/22	611
50	2/8/20	111	111	-			-		
52	29/7/20	94	188	-	29/12/20	428	-	17/2/21	428
53	30/7/20	86	172	-			-	17/2/21	344
59	27/7/20	255	255	-	29/12/20	317	-	6/1/21	287
61	5/8/20	101	101	-			-		
62	5/8/20	44	44	-	5/1/21	115	-		
63	27/7/20	519	519	-			-		
64	29/7/20	211	211	-	29/12/20	706	-	17/2/21	706
65	4/8/20	103	103	-			-		
66	29/7/20	79	79	-	29/12/20	175	-	17/2/21	136
67	26/7/20	285	570	-			-		
68	27/2/20	60.5	121	-	29/12/20	418	-		
68	14/8/20	67	134	-			-		
69	30/7/20	68	68	-	29/12/20	176	-	17/2/21	194
71	27/7/20	178	355	-	29/12/20	618	-	17/2/21	618
75	30/7/20	33	66	-	5/1/21	317	-	17/2/21	364
75	12/8/20	38	76	-			-		
78	6/8/20	234	234	-	5/1/21	471	-	17/2/21	471
79	5/8/20	123	123	-			-		
81	10/8/20	481	481	-	7/1/21	1051	-		
82				-			-	4/2/22	123
83	3/8/20	320	320	-	29/12/20	412	-	17/2/21	247
83				-	5/1/21	331	-		
86	16/8/20	100	100	-	28/12/20	57	-		
87	16/8/20	262	262	-	28/12/20	464	-		
88	16/8/20	107	214	-	28/12/20	192	-		

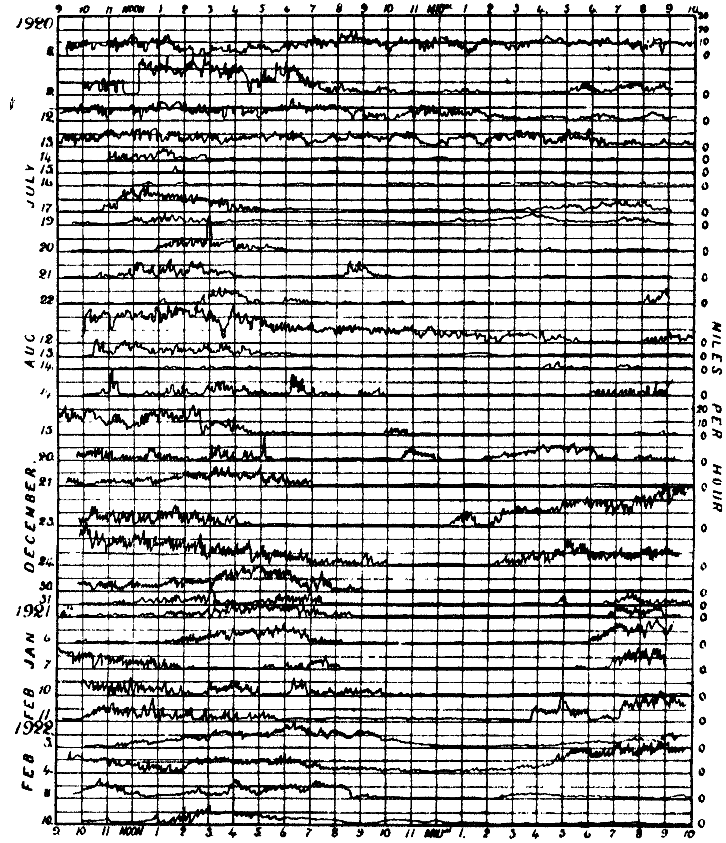
TABLE II.—TEMPERATURE RECORDS.

Thermometer Readings.

1920.		SOLAR.	DRY BULB.			WET BULB.					%HUMIDITY.		
		Max	9 a.m.	3 p.m.	9 p.m.	Max	Min	9 a.m.	3 p.m.	9 p.m.	9 a.m.	3 p.m.	9 p.m.
J'ly	8	104.7	50.3	56.9	52.0	52.0	45.0	47.2	50.8	48.5	77.0	62	76.0
	9	102.3	53.4	59.1	49.2	53.4	46.3	50.6	52.3	46.0	81.0	60	77.0
	12	84.0	47.1	53.6	49.8	48.7	40.0	44.1	48.7	46.2	77.0	68	74.0
	13	65.5	47.1	53.8	48.5	47.6	42.8	44.1	47.5	44.0	77.0	58	66.0
	14	84.2	49.0	54.4	49.8	50.2	42.1	46.0	50.1	48.8	78.0	72	93.0
	15	82.9	46.0	54.0	43.4	49.8	42.7	45.0	49.5	43.1	92.0	70	96.0
	16	96.8	38.7	55.0	45.0	49.5	35.5	38.6	48.5	43.7	99.9	59	88.0
	19	105.9	44.1	59.1	43.4	53.0	37.3	42.8	51.0	42.0	90.0	54	88.0
	20	101.5	40.3	60.1	45.9	52.2	33.6	39.4	51.8	44.5	87.0	54	89.7
	21	73.2	47.9	54.2	45.6	51.0	38.5	47.1	50.4	45.4	93.0	75	94.0
	22	97.5	46.4	52.6	45.2	48.2	43.0	45.0	46.8	43.0	89.0	61	82.0
Aug.	12	101.9	47.5	54.8	48.0	49.3	40.0	44.3	48.4	46.4	76.0	64	85.0
	13	101.9	48.0	54.0	47.2	50.2	42.8	47.0	49.1	46.3	92.0	68	93.0
	14	102.0	47.0	53.9	43.0	48.5	40.2	45.9	47.8	42.8	91.0	60	98.0
Dec.	14	146.3	76.1	84.6	71.0	69.9	59.8	67.8	67.0	64.0	63.0	36	66.0
	15	135.8	74.9	74.6	63.2	63.4	59.1	60.2	61.8	59.0	38.0	44	77.0
	20	146.3	79.7	91.1	77.3	66.6	50.2	64.3	65.3	61.3	39.0	19	35.0
	21	141.3	74.2	73.1	61.0	68.0	56.4	63.5	65.6	61.5	52.0	65	86.0
	23	155.9	86.5	105.8	83.9	73.6	58.8	70.0	73.3	67.5	41.0	17	40.0
	24	154.2	93.9	105.1	90.5	73.5	63.8	69.7	73.2	66.9	25.0	17	24.0
	30	143.1	72.6	83.1	67.0	67.5	56.3	63.1	67.2	60.7	56.0	40	68.0
	31	144.5	78.7	86.3	77.4	73.0	57.1	66.8	69.0	68.0	51.0	38	60.0
1921.													
Jan.	4	135.0	64.9	77.5	66.8	63.5	48.1	56.7	63.0	61.2	56.0	40	71.0
	6	149.0	79.0	88.6	77.0	71.9	60.6	69.9	69.7	69.3	62.0	26	67.0
	7	149.4	81.4	92.1	81.5	73.8	62.0	69.6	71.0	71.0	53.0	32	57.0
Feb.	10	149.0	84.0	94.0	71.9	72.3	55.5	65.0	69.5	67.2	31.0	24	76.0
	11	152.0	77.8	97.3	77.8	72.1	62.3	68.5	70.9	71.2	60.0	23	71.0
1922.													
Feb.	3	128.9	65.0	79.8	66.4	65.2	48.1	55.2	62.8	60.0	50.0	34	66.0
	4	142.5	73.1	88.0	71.3	66.7	51.9	63.9	63.2	64.8	58.0	19	68.0
	8	112.1	75.7	71.7	65.5	67.2	56.8	64.3	66.2	59.5	51.0	73	68.0
	10	133.9	72.0	86.3	71.6	72.1	58.2	65.7	71.5	70.0	70.0	46	79.0

TABLE III.

ANEMO-BIAGRAPH RECORDS.



Nos. 1 and 3. Pittosporum undulatum (Sweet Pittosporum).

Description.—Maiden, vol. VII., p. 123 (28).

Epidermis.—It was fairly easy to remove, the upper being much tougher than the under. It did not stain well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—There are none on the upper surface. On the under surface they are evenly distributed in the areas between the network of veins, except along the midrib and the larger veins, where they have a tendency to form in dense clusters. The highest number recorded was 450 per sq. mm. in one of these clusters. The average number was 320 per sq. mm. Twin stomata are of common occurrence and a pair can be seen on Plate XIV., No. 1. The average size is 24 x 19 micra, but there is a small percentage 29 x 23 micra.

The subsidiary cells have the long axes parallel to that of the pore and usually number two, seldom more. In these specimens, neither the guard cells nor the subsidiary cells stained well. The walls of the subsidiary cells are much thinner than those of the epidermal cells. Plate XIV., No. 1, Table XI., p. 225.

Glands and Hairs.— Absent.

Transpiration Experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225; Figs. 1 and 2, pp. 196 and 198.

The sudden rises of temperature shown on the mornings of the 23rd, 24th, and 26th, were due to the blind being raised on the east window, so that the sun shone directly on to the plant and the recording thermometer. The shade temperature reached its maximum in the tower at 2 p.m. each day, and the temperature curve shows that the maximum was reached between 2 and 3 p.m., except on the days when the sun was allowed to shine directly on the plant. Fig. 2, p. 198.

On 23/12/20, the younger leaves began to wilt at 10.45 a.m., and the transpiration rate fell; but at 2 p.m., water was added and towards 5 p.m. the plant recovered and the transpiration rate rose slightly. On 24/12/20, the highest record was 217. The young leaves were wilting at 2.10 p.m., so the plant was placed in the tower, watered, and it recovered in about 20 minutes. The shade temperature was then 104° F., and the water in the tin vessel was 108° F. Wind does not appear to affect the transpiration rate of this plant, and the high temperature did not make the old leaves wilt.

No. 6. BRACHYCHITON POPULNEUM (Kurrajong).

Description.—Maiden, VII., p. 77 (28).

Epidermis.—It is not very thick and on the under side is thinner than that on the upper side. The fact that the veins are so closely associated with the lower epidermis made it much more difficult to clear it from the underlying tissue. The cell walls did not stain well except in those cells outlining the strands.

Area.—See Table I., p. 184.

Stomata.—There are none on the upper surface. On the under surface they are regularly arranged in the areas bounded by the thicker-walled cells of the cuticle where it is attached to the strands. As in the leaf of No. 1, a fair portion of the area on the under side is taken up by these chains of cells which have no stomata. The highest number noted was 420 per sq. mm., the average being 310 per sq. mm. They do not vary much in size, but there are usually from 8 to 20% of a larger type. The usual size is 21 x 18 micra, the larger size being 31 x 26 micra. Plate XIV., No. 6, Table XI., p. 225.

The subsidiary cells are thin-walled and usually number only two, and their long axes are parallel with that of the pore.

Glands and Hairs.—Absent.

Transpiration Experiments.—Tables IV., V., and XI., pp. 194, 195, and 225; Fig. 6, p. 215.

On 24/12/20, the highest record was 219, so that the strong wind caused a decline in the transpiration rate. On 10/2/21, the younger leaves began to wilt at 2.45 p.m., and the next day the larger leaves showed light yellow patches.

No. 13. Casuarina Luehmanni (Buloke).

Description.—Maiden, Vol. II., p. 86 (28); Baker, p. 608 (3).

For an account of the anatomy of the Casuarinaceae see Solereder (40), Boodle and Worsdell (6), and Goeppert (19).

These trees are often found growing in large numbers over restricted areas on low-lying ground adjacent to sand hills. In rainy seasons, the ground in which they are living is water-logged for some time, but in dry seasons it becomes hard and cracked. The tree is shallow-rooted and, as a rule, the tap root divides before any great depth is reached. The lateral roots grow to great length, but do not increase in diameter much above an inch. Under the trees, the ground is matted with the fallen branchlets and the characteristic small disc-like fruits. The green wood is easily cut with an axe, but, when dry, it is one of the hardest of timbers. The main cracks appear along the medullary rays and very few are annular.

The *structure* of the branchlets agrees in the main with that of other members of the order, but, in this species, the branchlets are thicker and much more wiry. These characters tend to make each branchlet stand out more strongly by itself. There is less drooping and clustering of branchlets than in other species.

As a result of the reduction of the foliar organs, the young branches and branchlets are the chief assimilating organs of the plant. This function is carried on by means of an abundant supply of palisade parenchyma which is developed in the cortex of the young branch.

Leaves are really present but they are reduced to small teeth which form whorls at the node. The *branchlets* are formed of a series of internodes or joints, each of which forms a sheath at its upper end, and encloses the base of the internode above it. It terminates in from 7 to 10 teeth. The average of 101 readings for the specimen worked with was 8 on the branchlets and 10 on the larger branches.

Observations on the branchlets of three other species gave the following results:

C. Cunninghami, 5 teeth.
C. suberosa, 5 teeth.
C. Huegeliana, 9 to 10 teeth.

The *diameter* of the internodes of No. 13 varied from 1.5 to 1.75 mm., and the length from 7.5 to 10 mm.

Ridges.—The ridges or ribs which run the length of the internode are well defined and the corresponding grooves or furrows between them are plainly outlined. The ridges which have an

average width of .40 mm. are covered with an epidermis consisting mainly of small, narrow, elongated cells with a very thick cuticle in which are embedded the characteristic roundish, doubly-refracted bodies which, according to Solereder (40) are not oxalate of lime. The lateral walls of the elongated epidermal cells are thickened and pitted. Extending from end to end of the internode down the middle of each ridge is a narrow band of epidermal cells which are almost square in outline, and have very much thicker walls than the remainder of the cells covering the ridge. Plate XIV., No. 13 (a). The width of a ridge remains fairly uniform whatever the number forming the branchlet. On the larger branches, the average number of ridges is 10, and their width, .48 mm.—slightly more than on the smaller branches; but the grooves are not quite so deep, being .26 mm.

Grooves or furrows.—The walls of the furrows consist of 4 or 5 longitudinal rows of elongated cells, rectangular in outline, the walls of which are much thinner than those of the cells along the ridge and are not pitted. The height of the walls varies slightly: one averaging .16 mm. and the other .14 mm. The bottom of the groove consists of 3 or 4 rows of exceedingly narrow, much elongated, and very thick-walled cells, from which springs a closely packed line of hairs or trichomes. These seem to completely fill the groove and to extend somewhat above the walls, giving the furrows a hairy appearance when viewed from above.

Hairs.—These are of two kinds. Plate XIV., Nos. 13 and 13 (c).

(a) Simple trichomes consisting of two short comparatively thin-walled superposed basal cells supporting a longer terminal cell with thick walls.

(b) Branched trichomes consisting of two short and comparatively thin-walled superposed basal cells, supporting two long thick-walled cells, dichotomously inserted in the upper basal cell and forming an acute angle with each other. The dichotomous branching is often repeated in one or both of the branches. This description corresponds to that given by Poisson for the trichomes in *C. equisetifolia* var. *incarna.* Solereder, p. 787 (40). The hairs prevent dust and moisture from entering the furrows.

Area.—The measurements of the ridges and furrows were taken from a transverse section of an internode. Plate XIV., No. 13.

In this, the ridges stand out boldly and springing from the bottom of the furrows between them can be seen the trichomes, the tops of which bend over on to the ridges. The following method of measuring the area of the ridges and furrows and for examining the walls of the furrows was also adopted: the epidermis of an internode was slit with a razor longitudinally and then treated as described for removing the epidermis of leaves. The epidermis was removed and the whole flattened out on a glass slide. This enabled the width of the ridges and furrows to be checked, and

the walls of the furrows, and the hairs to be examined quite easily. The cell walls did not stain well with gentian-violet; but better results were obtained with Bismarck brown. The measurement of the area was arrived at as follows: From previous measurements of ridges and grooves the total circumference could be calculated, the total width of a ridge and the walls of a groove being .7 mm. Taking the average of 8 ridges to a branchlet, the total circumference would be 5.60 mm. Plate XIV., No. 13 (a).

The *length* of the branchlets was calculated by laying the plants flat on a sheet of cartridge paper, marking out the branches to the ends of the branchlets, and then drawing lines to represent these.

Chlorophyll containing tissue is restricted to the ridges and consists of three layers of radially elongated cells. This is shown on Plate XIV., No. 13, as two dark masses, one on each side of the ridge, but almost meeting in the middle. The remainder of the ridge consists of sclerenchymatous fibres elongated in longitudinal direction, and this extends to the outer limit of the cortical vascular bundle. There is no hypodermal parenchyma immediately beneath the epidermis as figured by Solereder, p. 778, Fig. 186 (40), for *C. equisetifolia*, also the amount of sclerenchymatous fibres in relation to the palisade parenchyma is greater in the ridges of *C. Luehmanni*. The circle of vascular bundles of the central cylinder can be plainly seen, and outside this circle the cortical vascular bundles may also be seen. A greater amount of sclerenchymatous tissue is present with the vascular bundles of *C. Luehmanni*, than is shown for *C. equisetifolia*. Apparently the strong wiry character of the branchlets is due to the specially thickened cell walls of the epidermis, and to the increased amount of sclerenchymatous fibre forming the ridges and associated with the vascular bundles.

On 10/8/20, the length of the branchlets totalled 1000 cm., and the branches 68cm., giving a total area of 621 sq. cm. As there are no stomata on the ridges, but only on the walls of the furrows, the transpiring area would be $1000 \times .24 + 68 \times .30$ cm. = 260 sq. cm.

The average number of ridges on the branches was 10, hence, the width of the stomatal area of an internode would equal .30 cm.

On 6/1/21, the transpiring area had increased to 330 sq. cm. by new growth. It increased somewhat more up to 17/2/21, but an equal amount of material was removed for examination, hence, the area is shown as the same on the two dates. Table I., p. 184.

Stomata.—These are found only on the walls of the furrows, on which they are arranged usually in four rows; but sometimes there may be only three rows on one side or the fourth row may have very few stomata in it. The stomata are placed at right angles to the direction of the furrow, and each is provided with two subsidiary cells lying with their long axes parallel with that of the pore. Plate XIV., Nos. 13 (a) and 13 (b). They are very uniform in size, the average being 31 x 18 micra. The length of the pore is very small compared with the length of the guard cells, being less than one-third of their length; and the junctions of the guard cells are strengthened.

The stomata are packed so closely together, that there are seldom two epidermal cells between pairs of them.

The following readings give the number of stomata per .35 mm. of the epidermis in the furrow:

Wall of Groove	11	9	—	—	11	8	11	11	1	11	10	9	10	10	10
	9	8	10	10	7	7	8	9	9	9	8	9	8	9	6
	4	8	10	1	7	11	8	9	9	5	8	7	8	8	10
*															
Wall of Groove	3	1	7	6	9	10	10	4	10	7	9	8	10	13	8
	9	8	7	9	6	8	10	11	11	10	9	13	8	10	7
	9	9	8	7	9	6	—	10	3	11	6	—	4	—	8
	—	4	—	—	—	—	—	—	—	—	—	—	—	—	2
Tot. per .35mm.	45	47	42	33	49	50	47	54	43	53	50	46	48	50	51

* = The strand along the base of the furrows to which the hairs are attached.

The average number per sq. mm. of transpiring surface was taken as 500.

Glands.—Absent.

Transpiration Experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225; Fig. 1, p. 184.

No. 14. FICUS MACROPHYLLA (Moreton Bay Fig Tree).

Description.—Maiden, Vol. I., p. 8 (28); Bentham, Vol. VI., p. 170 (4).

Epidermis.—The epidermis was easily removed. Though that on the under side of the leaf is much thinner than that on the upper, it is relatively thick. It stained fairly well.

Area.—See Table I., p. 184.

Stomata.—There are no stomata on the upper surface. On the under surface, they are fairly evenly distributed over the whole of the leaf within the network of thicker-walled cells which outline the veins in contact with the epidermis. There is a very slight tendency for the number to increase along the main veins. The highest number recorded was 170 per sq. mm., the average number being 120 per sq. mm.

The size varies very little, the average being 31 x 21 micra. The subsidiary cells are narrow, and the long axes are parallel to that of the pore. Plate XIV., No. 14, Table XI., p. 225.

Hairs and Glands are absent.

Transpiration experiments.—See Tables IV., V., X., and XI., pp.194, 195, 220, and 225; Figs. 1 and 7, pp. 196 and 221.

No. 17. ACACIA JUNIPERINA (Juniper Acacia).

Description.—Bentham, Vol. II., p. 331 (4).

In the specimens used the phyllodia were for the most part arranged roughly in whorls. In transverse section they are diamond-shaped, and at each angle is a narrow band of elongated epidermal cells, rectangular in outline, and with greatly thickened and pitted walls. A few of these can be seen on the lower side of the illustration on Plate XIV., No. 17.

Epidermis.—This was removed similarly to that of No. 13. It stained well with gentian-violet.

Area.—This was found in the same manner as that of the branchlets of No. 13. The area of a spine 9.4 mm. long was 12.54 sq. mm.

The length of the phyllodia varied from 4 mm. to 11 mm. Only a few were 11 mm., and the average of a large number of readings was 7 mm.

The area of the average phyllode was .09 sq. cm. Table I., p. 184.

Stomata.—They are very regularly and evenly arranged on each of the four faces of the phyllodia, as shown by the numbers counted on a phyllode 9.4 mm. long, which had been slit down one face.

The numbers on each face were 613, 636, 593, 574, making a grand total of 2416 stomata per phyllode. The average number for a phyllode 7 mm. long was taken as 1800, and the number per sq. mm. as 192.

On the stem there are longitudinal ribs or ridges similar to those on the phyllodia, but wider and stronger. The stomata are arranged on the sides of the ridges, leaving the area in the middle clear. There were 10 ridges on the main stem, and an average of 8 on the smaller branches; and there was an average of 290 stomata per sq. cm. of ridge.

They are uniform in size, but fairly small, being 23 x 18 micra; and are arranged with the long axis parallel to the long axis of the phyllode. The subsidiary cells are two in number, with the long axis parallel to the long axis of the pore. Plate XIV., No. 17, Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VIII., IX. and XI. pp. 214, 216, and 225; Fig. 6, p. 215. On 24/12/20, the plant was blown over, so no records were made before 11 a.m.

No. 19. ACACIA LINEARIS (Narrow-leaf Acacia).

Description.—Bentham, Vol. II., p. 399 (4).

The phyllodia are not rigid, but rather pliable and sway about easily in the slightest breeze.

Epidermis.—Is thick and tough, but was easily removed.

Area.—This was found by taking 19 types from the plant, and fitting every phyllode to one of them. Table I., p.

Stomata.—They are arranged very evenly on both sides and are

uniform in size. There is a slight tendency for the number to increase from the base to the apex, as shown by the average of a number of records per sq. mm.

	Apex		Middle		Base
(a) side ..	199	..	178	..	165
(b) side ..	203	..	182	..	168

The highest number recorded per sq. mm. was 230, the average number being 183 per sq. mm. The stomata are arranged with the long axis parallel to the long axis of the phyllode and usually parallel to each other.

Very little of the area is taken up with the strands which are few and narrow. The number of stomata near the strands is slightly greater than at a distance. They have a uniform size of 36 x 16 micra; and the subsidiary cells are two in number, with the long axes lying parallel to that of the pore. They did not stain so deeply as the other epidermal cells. Plate XIV., No. 19, Table XI., p. 225.

Glands and Hairs.— Absent.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225; Fig. 1, p. 196.

No. 22. Acacia montana (Mountain Acacia).

Description.—Bentham, Vol. II., p. 367 (4); F. v. M. (34).

Epidermis.—The phyllodia are very thin, and the epidermis is quite brittle to handle after being removed. The vertical walls of the cells are sinuate.

Area.— This was found by making tracings of each phyllode. Table I., p. 184.

Stomata are arranged evenly on both sides of the phyllode. There is very little tendency to crowd together even at the base. The long axes of the pores are not arranged parallel to one another. The highest number recorded per sq. mm. was 150, the average being 100 per sq. mm. for both sides. They vary very little in size, the average being 23 x 18 micra. A few larger ones, measuring 31 x 26 micra were noted. The guard cells are relatively large, and the pores small for the size of the stomata. The subsidiary cells are two in number, large, and the long axes lie parallel to that of the pore. Plate XIV., No. 22; Table XI., p. 225.

Glands.—These are numerous on both sides of the phyllode, the average number being 6 or 7 per sq. mm.

Hairs.—A few simple hairs are found along the central strand on both sides of the phyllode, and also along the edges.

Transpiration experiments.—See Tables VIII., IX., and IX.; pp. 214, 216, and 225; Figs. 6, p. 215.

No. 26. Acacia pycnantha (Golden Wattle).

Description.—Maiden, Vol. III., p. 137 (28); F. v. M. (33); Bentham, Vol. II., p. 365 (4).

Epidermis.—Thick, tough, and easily removed. It stained well with gentian-violet, except the subsidiary cells of the stomata.

Area.—Table I., p. 184.

Stomata.—The stomata are arranged regularly on both sides of the phyllode, but the long axes of the pores are not parellel to one another. The highest number recorded was 190 per sq. mm., the average for both sides being 146 per sq. mm. There is very little variation in the size, the average being 31 x 21 micra. The subsidiary cells are two in number, large, and the long axes are parallel to that of the pore.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 4, p. 205. On 10/2/21, the young phyllodia soon wilted, and parts of two began to turn yellow. Three very young ones at the apex were scorched and dropped off.

TABLE IV.—TRANSPIRATION RECORDS.

SERIES A. WINTER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour

1920. JULY	TIME FROM	NO. OF HOURS.	REGISTER NUMBERS OF PLANTS.										
			1 3	13	14	19	27 28	49	59	67	71	81	86
8	10-35	5.00	34	54	24	40	31	32	101	37	31	37	37
9	11-00	5.25	18	22	31	18	22	61	82	35	27	36	—
19	11-00	5.20	32	63	18	36	35	22	97	47	38	28	—
20	9-40	6.70	29	52	35	37	38	27	82	38	31	30	—
AUG.													
13	9-55	6.50	59	44	40	37	39	32	75	44	32	43	32
14	10-18	6.00	27	35	33	34	34	32	37	30	28	38	71
JULY.									DAY.		IN SHADE.		
15	12-30	4.50	0	0	10	4	4.5	8.5	6.6	15	1.7	14	—
21	9-30	24.0	0.8	0.7	1.9	1.8	1.8	2.2	6.3	1.8	1.3	1.0	—
22	9-30	6.80	17	1.5	12	18	12	10	33	14	6.0	10.0	—
JULY.									NIGHT.				
8	5-00	18.0	8.2	5.4	7.8	5.9	2.4	—	3.1	5.2	2.2	2.1	—
19	4-15	17.4	5.2	4.2	2.5	4.5	1.7	3.9	4.7	4.0	2.2	2.1	—
20	4-20	17.1	6.4	2.3	3.1	4.6	1.5	2.8	4.3	3.5	3.6	1.9	—
AUG.													
12	5-10	16.8	—	0.0	2.8	1.8	1.5	2.1	2.7	2.7	4.2	3.9	9.0
13	4-27	17.8	—	3.1	2.8	3.6	1.4	0.21	2.3	0.6	0.0	1.7	—

AUG.		DAY.	RESULTS FOR NO. 6	AND NO. 88
13	9-55	6.50	59	16
14	10-18	6.00	27	36
		NIGHT.		
12	5-10	16.8		4.7

NOTE:—On 21/7/20 and 22/7/20, the sky was overcast and there were some light showers and mist.

For *temperature* records see Table II., page 185.

For *wind* velocity records see Table III., page 186.

TABLE V.—TRANSPIRATION RECORDS.

SERIES A. SUMMER. DAY. IN SUN.

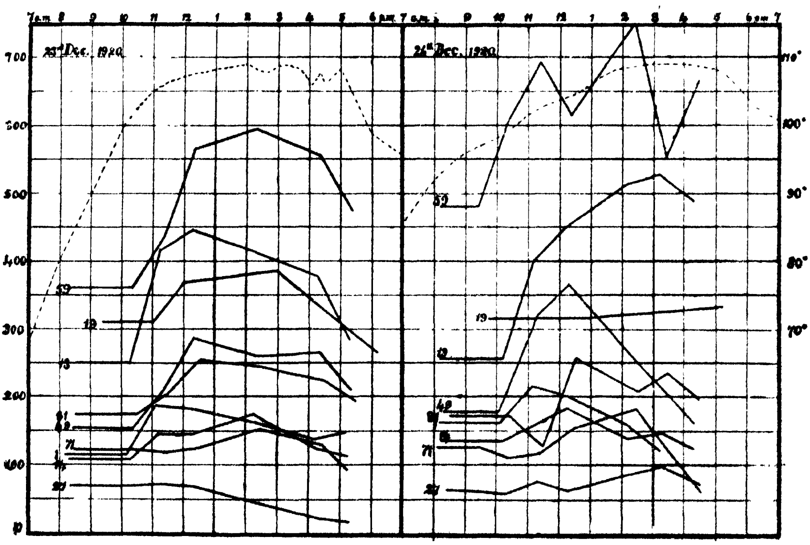
Records of Weighings in grammes per sq. metre per hour.

1920. Dec.	Time From.	No. of Hours.	Register Numbers of Plants. 1 3	6	13	14	19	27 28	49	59	71	81	86	88
14	9–30	22.0	14	9	18	10	25	11	16	20	9	21	23	114
15	8–30	8.6	73	61	148	91	195	92	108	212	75	103	215	106
								(27)						
20	11–30	3.0	100	94	242	75	247	20	170	338	91	171	264	164
21	9–00	3.0	112	71	170	112	191	41	133	312	93	133	194	99
,,	12–00	2.0	112	94	197	116	200	40	156	410	120	140	79	26
23	8–8	2.0	118	190	252	109	310	68	152	360	120	174	211	208
	10–8	1.0	188	190	415	147	310	71	209	436	120	204	211	208
	11–8	1.0	182	111	440	147	368	70	285	565	125	252	176	156
	12–12	2.0	163	312	415	172	384	43	260	595	154	244	317	174
	2–10	2.0	139	312	376	125	384	21	264	553	131	223	317	174
	4–8	1.0	149	152	298	113	264	16	205	474	83	192	216	110
24	8–10	2.0	164	219	254	136	315	60	177	544	120	175	52	208
	10–12	1.0	217	219	400	202	315	78	320	693	120	140	52	208
	11–10	1.0	202	219	450	182	315	63	365	616	154	253	52	208
	12–10	2.0	186	219	512	143	315	87	256	750	184	207	52	208
	2–10	2.0	124	164	525	147	332	96	209	553	128	246	211	171
	3–10	1.0	—	164	490	127	332	76	262	664	74	200	211	171
30	9–0	1.0	115		136	84	—	52	95	316	48	131	—	—
	10–0	1.0	102		197	68	—	74	133	316	91	118	—	—
	11–0	1.0	93		242	136	—	88	167	379	117	161	—	—
	12–0	1.0	118		212	170	—	74	175	389	142	157	—	—
	1–0	2.0	121		300	143	—	37	175	424	136	133	—	—
	3–0	1.0	139		340	154	—	23	167	379	128	104	—	—
31	8–30	2 0	—	139	—	—	220	—	—	—	—	—	—	156
	10–30	2.0	—	123	—	—	300	—	—	—	—	—	—	156
	12–30	2.0	—	139	—	—	251	—	—	—	—	—	—	135
1921. Feb. 10	10–40	2.0	178	242	300	140	—	56	190	455	88	—	—	—
	12–45	1.0	178	242	300	114	—	68	203	455	104	—	—	—
	1–45	1.0	207	236	419	117	—	76	214	494	93	—	—	—
	2–45	1.0	148	251	309	93	—	72	146	486	115	—	—	—
11	10–5	2.0	192	260	394	214	—	51	209	675	112	—	—	—
	12–5	1.25	—		436									
	12–5	2.0	172	221	363	191	—	27	200	649	120	—	—	—
	2–5	1.0	148	207	363	186	—	24	171	735	128	—	—	—

1920. Dec.	Time From	No. of Hours	Register Numbers of Plants.											
			1 3	6	13	14	19	27 28	49	59	71	81	86	88
1920. Dec.									Day.	Shade.				
30	9–0	3.0		49			100							42
	12–0	3 0		49			121							42
	3–0	1.1		2			98							14
31	9–0	2.0	93	—	188	79	—	30	123	212	75	66	—	—
	11–0	2.0	62	—	182	102	—	33	106	275	80	47	—	—
	1–0	2.0	81	—	203	61	—	44	131	218	78	46	—	—
1920. Dec.										Night.				
20	2–40	18.3	14	4.9	21	13	13	4.3	23	27	95	12	33	7.3
1921. Jan.														
4	8–0	1.0	—	—	36	23	16	1.5						
	9–0	1.0	28	41	24	23	5.2	3.2	0	11	11	12	—	13
Feb.														
10	3–45	18.3	38	30	48	26	—	6.5	27	—	19	—	—	—

For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

Fig. 1.—Transpiration Curves, Series A, Table V.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right temperature in degrees F. The temperature curve is dotted.

Nos. 27, 28, 29. ACACIA LONGIFOLIA (Sallow Acacia).

Description.—Bentham, Vol. II., p. 397 (4); F. v. M. (34).

Epidermis.—The epidermis of this phyllode as mentioned above is one of the toughest dealt with. It stained well with gentian-violet.

Area.—*Nos. 27 and 28*: The area was found by taking 19 types and comparing all phyllodia with these. *No. 29*: The area was found by making tracings of the phyllodia. Table I., p. 184.

Stomata.—They are arranged very evenly on both surfaces of the phyllode, the general direction of the long axes of the pores being parallel to the longitudinal venules. They are slightly more densely grouped along the main venules. The highest number recorded was 260 per sq. mm., the average being 155 per sq. mm. for both sides of the phyllode. The number tends to increase towards the apex. On No. 29 (the seedling) the average was 158 per sq. mm, the highest individual record being 270 per sq. mm. The size varies very little, the average being 35 x 27 micra.

On No. 29, the average size was 27 x 19 micra. There are two subsidiary cells, with the long axes lying parallel to that of the pore. Sometimes one or both of the subsidiary cells are divided into two by a thin transverse wall at right angles to the long axis of the pore. Plates XIV. and XV., Nos. 27, 27 (a), and 29; Table XI., p. 225.

Glands.—Absent.

Hairs.—On the phyllodia of the older plants a few simple hairs are scattered along the main venules; the number on the young plant is greater.

Transpiration Experiments.—See Tables IV., V., XI., pp. 194, 195, and 225; Figs. 1 and 2, pp. 196 and 198.

Nos. 27, 28. ACACIA LONGIFOLIA.

On 24/12/20, the strong wind which was blowing overturned the plant (No. 27) just after 10 a.m., and unsealed it. It was immediately watered, re-sealed, and again placed in commission. From an examination of the data for 23/12/20 and 24/12/20, it will be seen that the supply of water in the 6in. pot was insufficient for the plant for a day.

To test this plant further experiments were made on 6/1/21 and 7/1/21—two days on which the temperature rose to 90° F., or slightly over, and on each day there was a good breeze, but at different hours. See Table III., p. 186. Nos. 27 and 28 were used. They were well watered and a further supply of water was also put into the vessels in which the pots were standing, so that the bottom of the pot was under water.

On 6/1/21, hourly weighings from 9 a.m. to 12 noon gave transpiration results as follow: No. 27—80, 105, 108; No. 28—99, 88, 108.

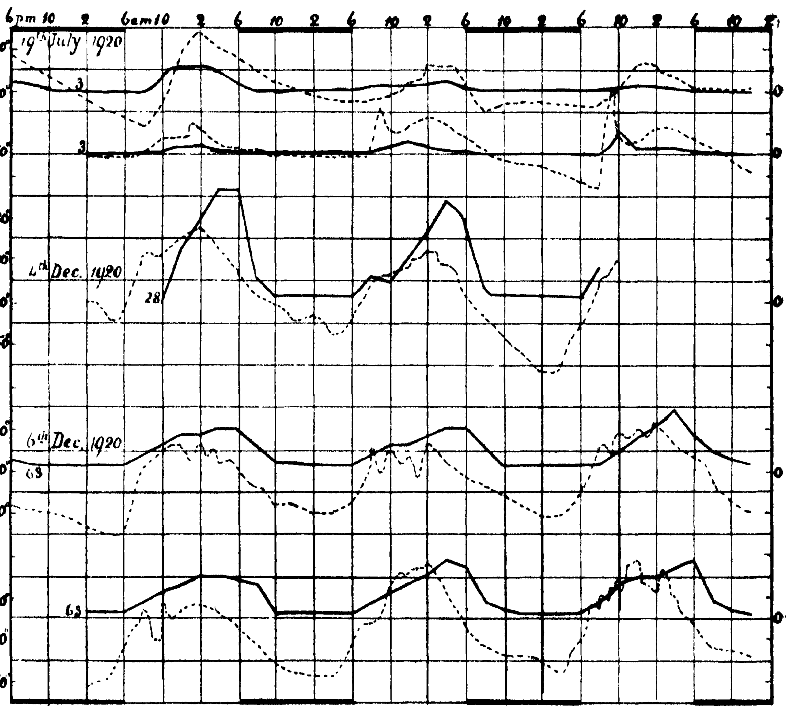
On 7/1/21, hourly weighings from 10 a.m. to 5 p.m. gave the following results with No. 27: 126, 131, 137, 106, 63, 37, 23, giving an average transpiration rate per hour of 90.

On 7/1/21, the weight of water in grms. given off per hour from 10 a.m. to 5 p.m. was as follows: 70, 73, 76.1, 59, 35.5, 20.5, 13, which gives 3.3 grms. per million stomata per hour for the day.

For 23/12/20 it was only 2.6 grms. per million stomata, so that it is evident that the water supply on 23/12/20 was insufficient. This plant has the lowest transpiration rate of any of the plants studied except No. 35. Even on the hottest day, when the water supply was insufficient, the old phyllodia did not wilt or turn yellow, as they did on the younger and smaller plant.

No. 28 was used on the transpiration balance from 10 a.m. on 4/12/20 to 8 a.m. on 6/12/20. The thermometer was not in the tower with the transpiration balance. Fig. 2, p. 198.

FIG. 2.—Records of experiments with Nos. 3, 28, and 63, on the Transpiration Balance.



The numbers opposite the abscissas on the left denote the temperature in degrees F.; those on the right the zero of transpiration. The temperature curve is dotted.

Transpiration experiments (No. 29). Tables VIII, IX., XI. pp. 214, 216, and 225; Fig. 6, p. 215.

In the final experiments on 10/2/21 and 11/2/21, the supply of water was insufficient, and on the 10th, some of the young

phyllodia had begun to droop, but recovered before next morning. During the 11th all the large phyllodia began to turn yellow, and the plant did not recover. The average transpiration rate of No. 29 is a little above that of Nos. 27 and 28 for the two days 6/1/21 and 7/1/21, when the water supply was adequate for the larger plants.

No. 31. ACACIA PODALYRAFOLIA.

Description.—Bentham, Vol. II., p. 374 (4).

Epidermis.—Is tough and easily removed.

Area.—Table I., p. 184.

Stomata.—Are distributed over both surfaces, the highest record being 260 per sq. mm., but the average number for both sides was 200 per sq. mm. They are uniform in size, the average being 29 x 16 micra. There are two subsidiary cells, and their long axes lie parallel to that of the pore. Plate XV., Nos. 31 and 31(a); Table XI., p. 225.

Glands.—Absent.

Hairs.—The whole of both sides of the phyllodia is covered with simple hairs, numbering between 30 and 40 per sq. mm. Plate XV., No. 31 (a).

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 4, p. 205.

No. 33. ACACIA SALIGNA.

Description.—Bentham, Vol. II., p. 364 (4).

Epidermis.—Stained well with gentian-violet, but not so deeply as in the other Acacias. It is noticeable, too, that the transverse cell walls are not so thick as in most of the others.

Area.—Table I., p. 184.

Stomata.—Are very regularly arranged, but sometimes the numbers increase towards the apex of the phyllode. The highest record was 350 per sq. mm. near the apex; but the average for both sides was 250 per sq. mm. They are fairly regular in size, and many of them are almost circular in outline, the average size being 23 x 20 micra. The subsidiary cells are two in number, with the long axes parallel to the long axis of the pore. They did not stain so well as the other cells of the epidermis. Plate XV., No. 33; Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 3, p. 201.

It was not used in the winter experiments. The highest summer record was 108 on 7/1/21.

This plant was weighed only on 6/1/21 and 7/1/21, and the following are the records.

		a.m.				p.m.			
	Time from . .	9	10	11	12	1	2	3	4
6/1/21	grms. per sq. . . .	88	80	73	—	—	—	—	—
7/1/21	metre per hr. . . .	—	110	101	102	102	108	99	100

It was placed on the transpiration balance on the evening of 24/12/20. Both the balance and the thermometer were in the tower. After the great heat on 24/12/20, the temperature fell very low on 25/12/20, but the temperature in the tower did not fall so quickly as outside. It will be noticed that, though the temperature curve falls for the greater period of the experiment, the transpiration curve rises and falls at about the usual times. Fig. 3, p. 201.

Nos. 34 and 35. ACACIA BAILEYANA (Cootamundra Wattle).

Description.—Maiden, Vol. IV., p. 8 (28).

Epidermis.—The epidermis, which is fairly thick, was removed in the usual way, and stained well with gentian-violet.

Area.—The leaves on each branch were counted and classified into three groups according to the number of pinnules—4, 6, or 8. The average number of leaflets for each of these types respectively was estimated at 84, 130, 197. The average area of a leaflet was taken as .05 sq. cm. Table I., p. 184.

Stomata.—They are very evenly arranged on both sides of the leaflets. The highest record was 280 per sq. mm., the average for both sides being 220 per sq. mm. The size varies very little, the average being 26 x 18 micra. The subsidiary cells are similar to those of No. 33. Plate XV., No. 35; Table XI., p. 225.

Glands.—Absent from the leaflets.

Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 4, p. 205. It has the lowest transpiration rate of any plant studied

Nos. 40 and 41. OXYLOBIUM ELLIPTICUM (Golden Shaggy Pea).

Description.—Bentham, Vol. II., p. 16 (4).

Epidermis.—Is thinner on the under side than on the upper. It stained well with gentian-violet, but unlike those of most stomata, the guard cells did not stain well.

Area.—Table I., p. 184.

Stomata.—A few are found on the upper epidermis scattered in irregular groups, the number increasing towards the apex. The under epidermis is divided into irregular four-sided areas by lines of elongated, fairly thick-walled cells to which the long simple hairs are attached. The stomata are evenly distributed within these areas as a rule, but sometimes are crowded at the apex. The walls of the guard cells are thin and collapse when treated in the acid solution. They are uniform in size, being 26 x 23 micra. The subsidiary cells are not so definite as in the Acacias. There are usually four, sometimes three, neighbouring cells associated with a stoma, and, of these, there are usually two —one on each side of the pore—with their long axes parallel to that of the pore. Plate XV., No. 40; Table XI., p. 225.

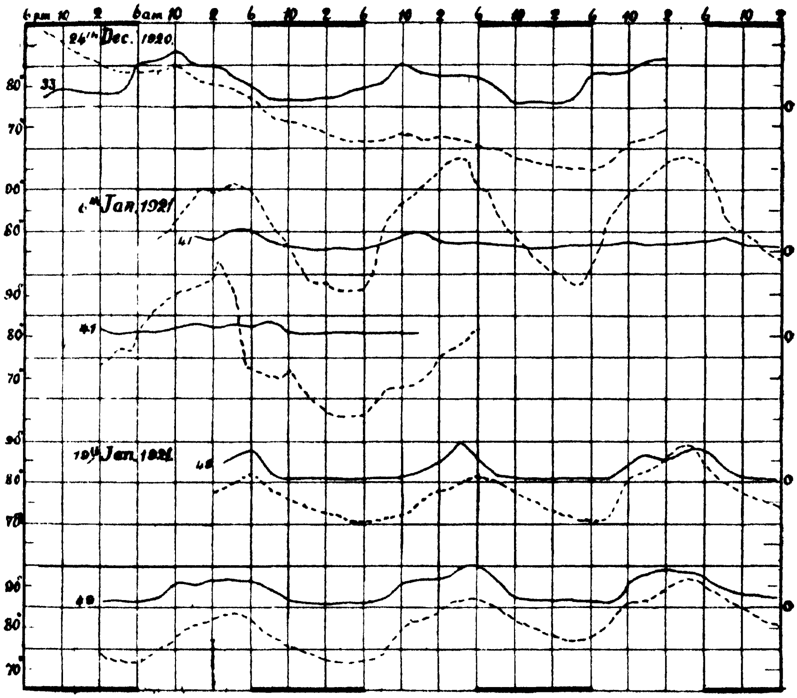
Glands.—Absent.

Hairs.—Both surfaces of very young leaves are densely packed with long, simple hairs; but, in adult leaves, they are absent from

the upper surface, and, on the under side, are crowded mainly along the midribs and larger veins.

Transpiration Experiments.—Tables VIII., IX., and XI., pp. 214, 216, and 225; Figs. 3 and 6, pp. 201 and 215.

FIG. 3.—Records of experiments with Nos. 33, 41, and 49, on the Transpiration Balance.



The numbers opposite the abscissas on the left denote the temperature in degrees F., those on the right the zero of transpiration. The temperature curve is dotted.

On 23/12/20, the young leaves began to wilt at 3.30 p.m., but the transpiration curve had begun to decline before that time. Water was added at 4.35 p.m., and the leaves were turgid again in 30 minutes.

On 24/12/20, the upper circles of leaves turned yellow on the upper side and the edges curled under at 2 p.m.; but the very young leaves were not affected. No. 40, which had been out in the open all the time, had its leaves raised almost parallel with the stem, but No. 41 had its leaves only slightly raised. Both plants received very severe shocks on 23/12/20, and were not used again.

The transpiration rate per million stomata for 23/12/20 was 6.2 grms. per hour; but this is a little below the normal, as the water supply was insufficient later in the day.

Nos. 42 and 43. OXYLOBIUM LINEARE.

Description.—Bentham, Vol. II., p. 17 (4).

Epidermis.—As in No. 40.

Area.—Table I., p. 184.

Stomata.—The number on the upper surface is greater than in No. 40 and they are more generally distributed, being about 60 per sq. mm.; otherwise, the arrangement agrees with that in No. 40.

The highest number recorded was 390 per sq. mm. near the midrib at the base of the leaf, the average number for the underside being 250 per sq. mm. The average for the whole leaf was 155 per sq. mm. The size is uniformly 26 x 18 micra; and the subsidiary cells are similar to those of No. 40. Plate XV., No. 42.

Glands and Hairs.—As in No. 40.

Transpiration Experiments.—See Tables VIII., IX., XI., pp. 214, 216, and 225; Fig. 6, p. 215.

No. 44. PULTENAEA DAPHNOIDES (Large-leaf Bush Pea).

Description.—Bentham, Vol. II., p. 112 (4).

Epidermis.—The epidermis is fairly thick and stained well with gentian-violet except the guard cells of the stomata.

Area.—Table I., p. 184.

Stomata.—On the upper suface of the leaf, there are a few stomata along each side of the midrib, and a single line, seldom a double line, along the main veins often extending to the edge of the leaf.

On the under side the stomata are arranged fairly evenly over the whole surface; but may be found in clusters near the apex. The highest record was 390 per sq. mm., but the average number was 250 per sq. mm. The usual size is 29 x 21 micra, but those on the upper side are slightly smaller. The subsidiary cells are similar to those of No. 40. Plate XV., No. 44; Table XI., p. 225.

Glands.—Absent.

Hairs.—There are a few arranged evenly over the whole of the under surface, but closely set along the midrib. The bases of two can be seen on Plate XV., No. 44.

Transpiration experiments.—See Tables VIII. and XI., pp. 214 and 225.

The plants did not grow well, so were not used in the summer experiments. The leaves moved into an erect position when the temperature rose above 100° F. on 23/12/20.

No. 47. PIMELEA FLAVA (Yellow Rice Flower).

Description.—Bentham, Vol. VI., p. 29 (4).

Epidermis.—The under epidermis is a little thinner than the upper. It stained well with gentian-violet.

Area.—Ten leaves were taken as types and all leaves were classified in size according to these. Table I., p. 184.

Stomata.—There are very few on the upper surface and these usually form a single line — sometimes double on a large leaf,

along the midrib. A few may also be found scattered about the apex away from the midrib. On the under surface they are evenly distributed over the whole of it. They are uniform in size, being 42 x 34 micra, and are larger than those of most of the plants studied, except one or two of the Eucalypts, and *Hakea gibbosa.*

The stomata are usually associated with 4 epidermal cells, but they can hardly be called subsidiary cells, for they are not arranged symmetrically with the stomata. (cf. Solereder, Vol. I., 717(40)). Plate XV., No. 47; Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VIII., IX., and XI., pp. 214, 216, and 225; Fig. 6, p. 215.

The leaves on this plant become almost erect when the temperature rises above 100° F., and they are exposed to the sun's rays.

No. 49. EUGENIA SMITHII (Lilly Pilly).

Description.—Bentham, Vol. III., p. 282 (4); F. v. M. (34).

Epidermis.—Was easily removed. On both sides it is thick and tough, but the tissues beneath separate off easily. It stained fairly well with gentian-violet. The vertical walls of the cells of the epidermis are sinuate.

Area.—Table I., p. 184.

Stomata.—There are no stomata on the upper surface, but they are fairly evenly distributed over the whole of the under surface with a tendency to crowd along the midrib and at the apex. The highest record was 300 per sq. mm., the average being 230 per sq. mm. They vary little in size, and on the average measure 31 x 26 micra. The pore is short compared with the length of the guard cells. The stomata are associated with 4 or 6 cells adjacent to them, but these cannot be called subsidiary cells. Plate XV., No. 49; Table XI., p. 225.

Glands.—Are numerous on both sides, averaging from 5 to 7 per sq. mm.

Hairs.—Absent.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225, Figs. 1 and 3, pp. 196 and 201.

There was no change in the foliage of the plant at the conclusion of the experiments.

The experiment on the transpiration balance continued from the 19th to 24/1/21, both the thermometer and the transpiration balance being in the tower.

Changes were not so abrupt inside the tower. Here again the transpiration curve roughly coincides with the temperature curve, except at night, when the transpiration rate varies very little, it was at its lowest usually between 2 a.m. and 3 a.m. Fig. 3, p. 201.

No. 50. EUGENIA MYRTIFOLIA.

Description.—Bentham, Vol. III., p. 286 (4).

Epidermis.—Not so easy to remove as that of No. 49, but the cells are similar in shape.

Area.—Table I., p. 184.

Stomata.—There are none on the upper surface. On the under surface they are fairly evenly arranged, but tend to increase in number from base to apex, and also to form clusters near the midrib or near the veins. The number varies on different leaves, the older, larger leaves having less per sq. mm.

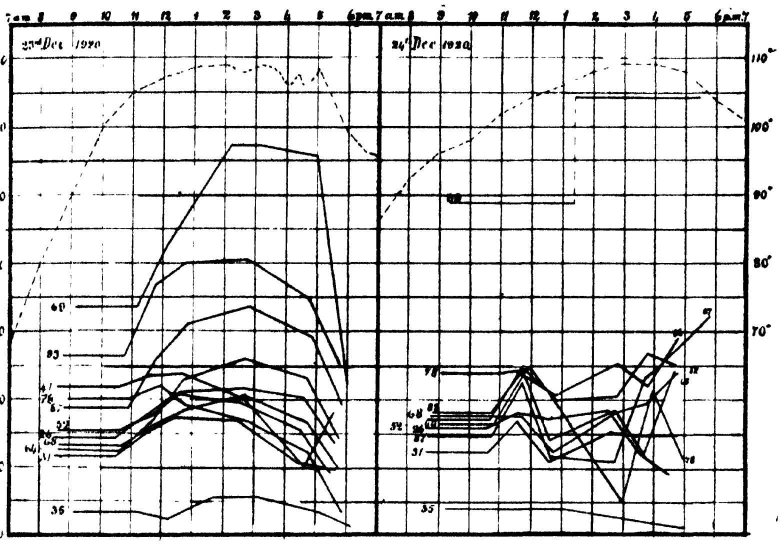
TABLE VI.—TRANSPIRATION RECORDS.

SERIES B. WINTER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920 July.	Time From	No. of Hours	Register Numbers of Plants.											
			26	31	34 35	40	50	52	64	58	69	78	83	87
9	11–45	5.0	38	15	32	67	43	54	52	55	76	21		
13	11–15	5.0	24	14	12	31	38	28	25	13	56	2.6		
16	11–15	4.8	26	59	44	27	47	55	82	50	76	7.3		
19	11–20	4.8	34	37	36	103	56	59	98	59	104	—	62	
20	9–15	6.8	31	52	31	91	40	56	80	50	102		56	
Aug.														
13	10–0	6.5	58	62	41	83	—	—	78	42	91	11	72	32
14	10–30	6.0	56	45	42	105			58	60	88	16	78	37
July.								Day.		In Shade.				
15	9–15	6.7	7.5	8.1	13	30	27	21	21	12	26	12		
21	9–30	24.0	1.4	1.1	0.8	2	6.3	3.7	4.2	1.6	8.8		6.2	
22	9–40	6.6	0	4.3	12	23	19	17	11	17	26		23	
July.										Night.				
8	4–30	18.0	2.3	3.2	3.1	18	10	6.9	6.6	4.1	13	2.1		
13	4–40	17.0	4.4	3.5	3.9	2.6	14	6.4	6.1	10	9.6	4.7		
14	9–40	23.3	1.9	0	2.9	7.0	2.7	3.2	3.8	0.8	12	0.86		
15	3–45	19–5	4.7	3.8	1.8	1.1	2.7	3.2	4.7	0.0	10	1.3		
19	4–15	17.5	1.9	1.6	2.9	5.0	11	8.0	7.5	5.0	1.5	10		
20	4–20	17.5	1.9	0.0	1.0	5.0	16	5.8	5.2	5.8	12	7.1		
Aug.														
12	5–5	16.7	2.3	0.5	0.26	6.0			4.7	4.1	8.8	1.7	6.8	2.3
13	4–30	18.0	0	0	1.3	2.0			3.8	0	7.4	0	5.0	0

FIG. 4.—Transpiration Curves, Series B, Table VII.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right, temperature in degrees F. The temperature curve is dotted.

TABLE VII.—TRANSPIRATION RECORDS.

SERIES B. SUMMER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920. DEC.	TIME FROM	NO. OF HOURS.	Register Numbers of Plants. 26	31	34 35	40 41	52	64	68	69	78	83	87
15	9-10	8.5	98	84	20	158	95	134	58	206	117	160	98
20	10-0	4.0	89	102	30	215	147	37	125	294	220	200	157
21	8-30	3.0	98	90	33	101	126	143	120	320	150	221	135
21	11-25	2.0	76	112	30	76	110	171	137	340	157	232	144
23	8-30	2.0	145	117	35	207	154	126	132	334	200	264	188
	10-30	1.0	172	150	26	234	175	168	161	427	221	366	260
	11.30	1.0	206	173	57	238	210	228	183	570	189	396	310
	12-30	2.0	199	172	57	200	216	260	202	570	166	404	337
	2-25	2.0	157	108	36	103	202	243	168	555	121	348	292
	4-25	1.0	94	98	17	183	140	148	103	228	38	252	194

1920 DEC.	TIME FROM	NO. OF HOURS	Register Numbers of Plants. 26	31	34 35	40 41	52	64	68	69	78	83	87
24	8-30	2.0	158	123	38	127	171	160	173	485	237	177	147
	10 30	1.0	170	169	38	167	246	238	173	485	242	240	227
	11-30	1.0	160	110	38	156	140	196	122	485	185	202	114
	12-20	2.0	182	153	13	206	185	203	180	640	65	252	106
	2-30	1.0	126	148	13	216	122	266	192	640	210	216	227
	3-30	1.0	92	150	13	175	241	252	240	640	115	288	320
30	9-20	1.0	138	101	37	81	129	140	72		88	156	
	10-20	1.0	131	80	55	69	105	161	125		126	144	
	11-20	1.0	150	117	47	89	117	172	110		89	146	
	12-20	1.0	158	97	78	89	164	185	142		258	106	
	2-20	2.0	92	179	85	106	152	228	139		260	127	
	3-20	1.0	102	118	66	95	140	182	120		185	120	
31	9-25	2.0								336			
	11-25	2.0								348			
	1-25	2.0								388			
1921. FEB. 10	11-0	2.0	154				82	168		129	143		
	1-3	1.0	147				117	224		160	346		
	2-10	1.0	136				140	254		278	382		
	3-10	1.0	90				117	195		180	267		
11	10-30	2.0	88				164	123		201	178		
	12-30	2.0	88				187	125		206	95		
	2-30	1.0	88				164	168		248	95		
1920. DEC.									Day.		Shade.		
30	9-20	6.0								161			
31	9-25	2.0	44	65	46	46	82	123	89	336	101	89	
	11-25	2.0	51	75	46	68	89	137	70	348	109	60	
	1-25	2.0	32	88	50	76	66	157	65	388	105	50	
1920. DEC.									Night.				
20	2-0	18.4	14	16	4.0	32	19	13	18	52	23	52	17
1921. JAN. 4	8-30	2.0	9	9	5	0	-	7	7	74	7		
FEB. 10	10-30	18.3	13				28	25		36	25	36	

For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

The highest record was 860 per sq. mm., the average being 540 per sq. mm. They are uniform in size, being 21 x 18 micra. The stomata are more definitely associated with the cells lying to right and left of them, hence, these may be considered as subsidiary cells. Plate XV., No. 50; Table XI., p. 225.

Glands are not so numerous as in No. 49.

Hairs.—Absent.

Transpiration experiments.—See Tables VI. and XI., pp. 204 and 225. The leaves became diseased, and the plant was not used in the summer experiments.

Nos. 52 and 53. EUCALYPTUS MACRORRHYNCHA (Red Stringybark).

Description.—F. v. M., Dec. 1 (32); Maiden, Vol. VIII., p. 225 (27).

Epidermis.—The epidermis was not easily removed. It stained well with gentian-violet.

Area.—On 29/7/20, there were 13 leaves, the area of the largest being 11.9 sq. cm. Nine of these had the characters of juvenile leaves. On 29/12/20, there were 23 leaves, the area of the largest being 20.0 sq. cm. Five of these had juvenile characters. Table I., p. 184.

Stomata.—There is a slight tendency to clustering along the midrib and main veins. On the juvenile leaves the numbers on the two sides vary.

The highest records for each side were (a) 150, and (b) 330 per sq. mm.

The average for each side was (a) 110, (b) 270 per sq. mm. Plate XVI., Nos. 52 and 52 (a).

On the older leaves, from which the hairs are absent, the highest records were (a) side 190, (b) side 390 per sq. mm., the average for each side being 160 and 270 per sq. mm. respectively. The average for the whole plant was taken as 210 per sq. mm. The size varies a good deal in growing leaves, but there is not much difference between those on opposite sides of the same type of leaf. Those on the leaves without hairs are slightly larger than those on the younger type of leaf. The average size is (a) side, 31 x 23 micra; (b) side, 34 x 26 micra. Plate XVI., 52 (b).

The stomata are surrounded by 3 or 4, seldom more, irregularly arranged subsidiary cells, which stain slightly deeper than the remainder of the epidermal cells — so stand out more plainly in the preparation.

Glands and Hairs.—They are associated in these leaves; the numerous glands on both sides of the juvenile leaf—10 per sq. mm. —being surrounded by simple hairs with broad bases, the number varying from 5 to 12 per gland. These clusters of hairs give the leaves and stems a rough appearance (cf. F. v. M., Dec. 1 (32)). Plate XVI., No. 52 (a).

The hairs are not stellate, but each simple hair is developed from one of the epidermal cells surrounding the gland (c.f. Maiden, Vol VIII., p. 225 (27)).

Transpiration experiments.—See Tables VI., VII., XI., pp. 204, 205, and 225; Fig. 4, p. 205.

Nos. 59 and 61. EUCALYPTUS BOTRYOIDES (Gippsland Mahogany).

Description.—F. v. M., Dec. IV. (32); Maiden, Vol. III., p. 50 (27); Bailey (1); F. v. M. (63).

Epidermis.—The epidermis is thick, tough, and easily removed.

Area.—Table I., p. 184.

Stomata.—On the upper surface, there are usually a few stomata along both sides of the midrib. On the under surface they are arranged fairly evenly over the whole surface, but clusters may be found in the middle of the leaf. The highest record for No. 59 was 740 per sq. mm., the average being 610. On No. 62 (one year old seedling) the epidermis was too thin to remove. The leaf was treated with a weak solution of nitric acid, stained, and examined between two large cover-slips. There were very few stomata on the upper side and the highest record on the under side was 330 per sq. mm., the average being 280. They are very uniform in size, being 42 x 31 micra on the larger, older leaves, and 26 x 21 micra on the younger. The subsidiary cells are similar to those of No. 52. Plate XVI., No. 59; Table XI., p. 225.

Glands.—Average about 5 per sq. mm.

Hairs.—Absent.

Transpiration experiments.—See Tables IV., V., XI., pp. 194, 195, and 225; Fig. 1, p. 196. The highest summer records were 592 on 23/12/20, and 750 on 24/12/20. This plant has the highest transpiration rate of any of the plants studied. On 24/12/20, the transpiration rate rose high above that of the day before, so that it was apparently increased by the high wind velocity. The only change noticed in the foliage during the course of the experiments was that the very small leaves at the top were slightly scorched on 10/2/21. Even the heat and wind on 24/12/20 did not scorch the leaves, although some of the Eucalypts growing in the enclosure had their young leaves scorched, and all the leaves of the elm trees along Sydney Road were scorched, turned yellow, and fell in a few days.

Nos. 63, 64, and 66. EUCALYPTUS GLOBULUS (Blue Gum).

Description.—Maiden, XCVII., p. 249 (27); F. v. M. (34).

Epidermis.—Was fairly difficult to remove, as it is comparatively thin and easily breaks up, especially that on the under side.

Area.—Table I., p. 184.

Stomata.—The number of stomata varies a good deal with the shape, size, and age of the leaf. There is a tendency to cluster in the middle parts of the leaf.

On the upper surface there are always a number scattered along each side of the midrib, and usually a few along the main veins. Plate XVI., No. 64 (b)

On the under side, the highest records were 1030, 1020, 970, 960 per sq. mm. on a few leaves.

The following table gives the data from a number of leaves of different sizes taken from the same plant:

No. 64 (Second Year Plant, with juvenile leaves):

Leaf.		Area in sq. cm.		Avge. no. stomata per sq. mm.		Highest no. recorded.
a.	..	59.3	..	190	..	290
b.	..	48.0	..	173	..	260
c.	..	19.3	..	315	..	430
d.	..	4.0	..	400	..	600
e.	..	4.0	..	186	..	200
f.	..	5.6	..	190	..	230

No. 66 (First Year Plant, with juvenile leaves):

a.	..	19.2	..	141	..	190
b.	..	13.8	..	178	..	260
c.	..	13.0	..	209	..	260
d.	..	12.7	..	172	..	210
e.	..	9.0	..	152	..	200

The average number of stomata for No. 64 was 240 per sq. mm. Plate XVI., Nos. 64 and 64 (c). A branch with juvenile leaves was taken from an old tree and the stomata estimated, the average being 220 per sq. mm.

The number on an adult leaf was counted for comparison, and some of the records were as follow:

(a) side	50	50	67	55	per sq. mm.
(b) side	80	146	182	147	per sq. mm.

(cf. F. v. M., Dec VI. (32)). Plate XVI., No. 64 (a).

The size of the stomata varies a good deal. The highest record on juvenile leaves was 39 x 26 micra, the average size being 29 x 23 micra. On the adult leaf the average was 65 x 55 micra. The subsidiary cells are similar to those of No. 52.

Glands.—Are fairly numerous, on the under side only.

Hairs.—Absent.

Transpiration experiments.—See the following tables and figures. For No. 63: Fig. 2, p. 198. No. 64: Tables VI.,VII., and XI., pp. 204, 205, and 225; Figs. 4 and 5, pp. 205 and 213. No. 66: Tables VIII., IX., and XI., pp. 214, 216, and 225.

No. 63 was used only on the transpiration balance in the summer experiments. Fig. 2, p. 198.

No. 64 was also used on the transpiration balance. See Fig. 5, p. 213.

Transpiration experiments.—Interesting points to notice are that there was a fair amount of transpiration during the night, that the lowest point was reached at about 6 a.m., and that the maximum

transpiration lagged behind the maximum temperature. No. 63 was used on the transpiration balance on 6/12/20 to 12/12/20. The plant was in the tower and the thermometer in the meteor shed. The curve is very like that of No. 64. It will be noticed that the maximum transpiration was usually between 4 and 6 p.m.—much behind what it was outside in the sun. The maxium temperature was over 20° below that of the 31/12/20, but the transpiration curve followed the temperature curve, and the transpiration at night was much lower. Sudden changes in temperature, unless very great, affected the transpiration curve very little.

No. 66. Not many records were made of No. 66. The daily average transpiration rate on 23/12/20 was 102, and on 24/12/20 was 233, so the wind apparently greatly increased the transpiration rate of the seedling.

Nos. 67 and 68. Eucalyptus alpina (Grampians Gum).

Description.—F. v. M. (31), (32), (34).

Epidermis.—The adult leaves have such a thick epidermis and the tissues beneath are so closely associated with it, that it was not possible to remove the epidermis as a whole, so it was removed in strips. The whole of the tissues of the leaf beneath the epidermis consist of rows of palisade cells, reticulated with large secretory canals. The juvenile leaves are rough-looking, but soft. The venules are prominent on the under side. Care was needed to remove the epidermis whole, as it is fairly thin and closely associated with the venules.

Area.—Table I., p. 184.

On 29/12/20, No. 68 had 40 leaves, the total area being 209 sq. cm. Nine of these leaves were smooth and more like adult leaves, the other 31 appeared warty and rough.

Stomata.—On No. 67 (adult), they are arranged evenly over both surfaces in small clusters. On the upper surface, they are sunk to the lower level of the epidermis, and are not so numerous as on the underside. Plate XVI., Nos. 67 (a), 67 (b), and 67 (c). The highest record for the upper side was 170 per sq. mm, the average being 110. The highest record for the under side was 200, the average being 152 per sq. mm. The average for both sides was 132 per sq. mm.

F. v. M., in Eucalyptographia, Dec. 1, gives 70 and 90 per sq. mm. in the adult, so probably the specimens were taken from an older tree.

On No. 68 (the Seedling), the number varied with the size and the age of the leaf. The highest record for the upper side was 360, the average being 120 per sq. mm. The highest record for the under side was 570, the average being 284 per sq. mm.

Where the record was high, there was no gland with its ring of hairs in the field; but usually a gland or part of a gland took up part of the field when counting the stomata. A few records will

show the difference. They are taken from the under side of the leaf:

No gland in the field .	—	430	570	430	510	—	—
One gland in the field .	330	290	230	260	180	150	90

On No. 67 (adult), the size is uniform. On the upper side the average is 70 x 65 micra; on the under side 52 x 47 micra. They vary more in No. 68 (seedling) than in the adult, the average sizes being as follow: Upper, 31 x 26 micra; under, 29 x 18 micra. Plate XVII., No. 68. The subsidiary cells of No. 67 consist of either six or eight, more or less, elongated cells closely associated with each stoma, which stained slightly darker than the other epidermal cells. On No. 68, they are similar to those of No. 52.

Glands.—On No. 67, the average number is about 1 per sq. mm. on both sides, although they are slightly more numerous on the under side. The greater number are about the size of the large stomata, and at first sight might be taken for stomata, but the epidermal cells associated with them have their long axes parallel to the radii of the gland, are narrow, and their thick lateral walls advance to the inner walls of the gland, the opening of which is partly closed by a membrane. The very large openings of the excretory cavities have no protection over the openings.

On the upper side of the leaves of No. 68 there are from 5 to 6 glands per sq. mm., and on the under about 3 or 4 per sq. mm. They are surrounded by a number of simple hairs. Plate XVII., No. 68 (a).

Hairs.—No. 67: Absent.

No. 68: On both surfaces there are numerous simple hairs associated with the glands as in No. 52, but the number per gland is greater than in No. 52, also the hairs on the upper side are shorter and more numerous than those on the under side. Plate XVII., No. 68 (a).

Transpiration experiments.—See Tables VI., VII., XI., pp. 204, 205, and 225; Fig. 4, p. 205.

No. 69. EUCALYPTUS CLADOCALYX (Sugar Gum).

Description.—F. v. M. (31), (32), (34); Maiden, Vol. IV., p. 161 (27).

Epidermis.—Was removed fairly easily and stained well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—On the upper side of the leaf there are always a few stomata along each side of the midrib to about the middle of the leaf; and one or two may be found along the main veins. On the under side they are arranged evenly all over the surface. The highest record was 410 per sq. mm. The average for the smaller, younger leaves is 320; for the larger, older leaves 220 per sq. mm. They are uniform in size, being 31 x 23 micra. The subsidiary cells are similar to those of No. 52. Plate XVII., No. 69.

Glands.—Average about 1 per sq. mm. on the under side.

Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 226; Fig. 4, p. 205.

The highest summer records were 570 on 23/12/20 and 640 on 24/12/20. Its transpiration rate is second only to No. 59. The wind on 24/12/20 greatly increased the transpiration. Temperatures over 100° F. seemed to cause excessive transpiration in this plant. Its curve always followed closely on the temperature curve. On 10/2/21, the upper leaves wilted a little and the transpiration rate dropped quickly. On 23/12/20, and on other very bright, hot days, the edges of the leaves curled upwards.

No. 71. EUCALYPTUS MACULATA, var. CITRIODORA (Sweet-scented Gum).

Description.—Bailey (1) and (2); Maiden, Vol. I., p. 154 (28); F. v. M. (31).

The first juvenile leaves averaged about 5 inches when measured on 26/7/20, but on 29/12/20, when the next measurement was made, none of the first leaves was present, and the new ones averaged about 3½ inches in length.

Epidermis.—The epidermis of the juvenile leaves was very difficult to remove whole, as it is very thin on both sides of the leaf. It did not stain very well with gentian-violet, but the glandular hairs did.

Area.—Table I., p. 184.

Stomata (Juvenile leaves).—They are found on both sides of the leaf, the greater number being on the under side. They are often densely packed at the apex and also increase in number from the margins to the midrib. They have a tendency to form clusters about the glandular hairs. On the upper side, the highest records were 550, 410, and 280 per sq. mm., but the average number was 160. On the under side, the highest records were 710, 650, and 640 per sq. mm., but the average number was 460, hence, the average for the two sides was 310 per sq. mm. Plate XVII., Nos. 71 and 71 (b).

The *Adult leaves* were obtained from a large tree. Stomata are found on both sides. The average for (a) side was 366, for (b) side 330 per sq. mm. F. v. M. (32) gives the numbers as follow: (a) side, 153 and 180; (b) side, 205 and 225 per sq. mm. Plate XVII., No. 71 (c).

They are fairly uniform in size, although there is usually a small percentage of larger ones on the under side.

Juvenile—	
Upper epidermis	21 x 16 micra
Under epidermis	18 x 16 micra
,, large size	26 x 21 micra
Adult—	
Both sides	21 x 16 micra

The subsidiary cells are similar to those of No. 52.

Glands.—On adult leaves there are few. On juvenile leaves, the glands are numerous on both sides, and have a peculiar structure.

"Is specially noteworthy owing to the fact that in the long narrow leaves and in the branches the secretory cavities are enclosed in hair-like emergencies of cylindrical shape, rounded at the ends, and of epidermal origin." Solereder, Vol. I., p. 353 (40).

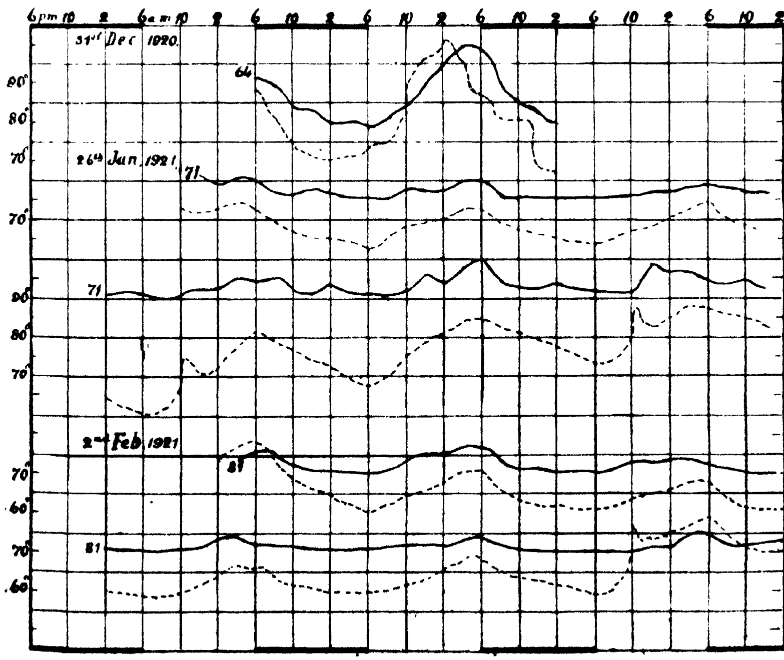
On the upper epidermis, these glandular hairs are shorter than on the under side. They are arranged more or less in groups, and especially along the smaller venules. On the upper side, they average 5, and on the under side, 10 per sq. mm.

Hairs.—Are associated with the glands.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 226; Figs. 1 and 5, pp. 196 and 213. Only when the temperature rose some distance above 100° F. did the transpiration rate rise above 150.

This plant was used on the transpiration balance from 26/1/21 to 31/1/21. Both plant and thermometer were in the tower. Fig. 5, p. 213. The maximum temperature rose higher each day, but the sudden rises on 29/1/21 and 31/1/21 at 10 a.m. were due to raising the blind on the east window of the tower. There was no change in the leaves on completion of the experiments, and the plant grew well afterwards.

FIG. 5.—Records of Experiments with Nos. 64, 71, and 81, on the Transpiration Balance.



The numbers opposite the abscissas on the left denote the temperature in degrees F.; those on the right the zero of transpiration. The temperature curve is dotted.

No. 75. LEPTOSPERMUM LANIGERUM (Woolly Ti-tree).

Description.—Bentham, Vol. III., p. 106 (4).

Epidermis.—This was removed fairly easily, but did not stain well with gentian-violet.

Area.—Was found in the same way as those of Nos. 27 and 47. Table I., p. 184.

Stomata.—Are evenly arranged on both sides. The highest records for both sides were 350, 330, 300, and 260 per sq. mm., and the average for both sides was 240 per sq. mm. The size was uniform on both sides, the average being 23 x 21 micra. The subsidiary cells are similar to those of No. 52. In many cases the cells on each side have their long axes parallel to the pore, and look more like subsidiary cells. Plate XVII., No. 75.

Glands.—Are arranged evenly on both surfaces; but the average for the upper surface is 20, while that of the under surface is 12 to 15 per sq. mm.; but the latter are slightly larger.

Hairs.—Long, thin unicellular hairs are arranged sparsely over most of the upper surface, but densely along the midrib and edges. There are none on the under side.

Transpiration experiments.—See Tables VIII., IX., XI., pp. 214, 216, and 226; Fig. 6, p. 215.

On 10/2/21, when the water supply was meagre, the transpiration rate soon fell, and the leaves wilted although the soil was damp, but they soon recovered when watered.

TABLE VIII.—TRANSPIRATION RECORDS.

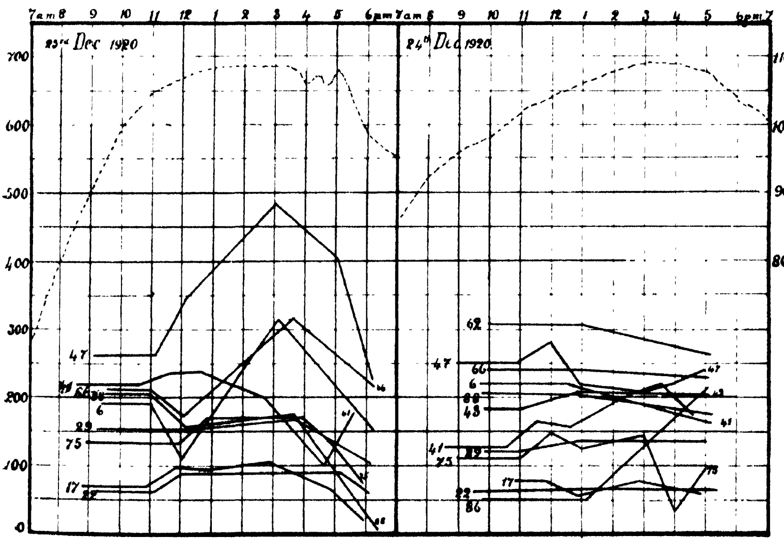
SERIES C. WINTER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920. JULY.	TIME FROM	NO. OF HOURS	REGISTER NUMBERS OF PLANTS.									
			17	22	29	42	44	47	53	62	66	75
16	10-40	5.2	30	35	50	42	98	89	74	57	25	22
19	2-0	2.5	18	88	56		33	74	41		13	21
20	10-0	6.7	30	29	50	50	113	110	64		76	33
AUG.												
13	10-30	6.5	30	44	69	62	115	111	58		25	26
14	11-10	5.8	22	59	23	82	105	100	48		13	26
JULY.						DAY.	SHADE.					
12	12-0	3.8	23		11	30	26	78	17			26
13	9-30	6.3	11	9	13	12	20	44	19	16	25	15
15	9-50	4.7	12	6	14	12	16	37	12	23	9	33
22	10-45	6.0	15	7		6	16	37	17			10

1920. JULY.	TIME FROM	NO. OF HOURS.	REGISTER NUMBERS OF PLANTS. 17	22	29	42	44	47	53	62	66	75
JULY.								NIGHT.				
12	4-0	17.6	3.0		0.0	3.7	3.3	11.0	4.6			4.7
13	4-0	17.3	2.7	2.9	8.3	6.2	0	3.7	5.2	11	6.3	7.3
14	9-20	24.5	2.7	0	0	2.5	3.3	11	2.9	5.9	3.8	1.5
15	4-30	18.3	0.6	0	1.4	0	3.3	7.4	3.5	0	2.5	2.1
19	4-40	17.5	3.0	2.9	6.9	7.5	4.9	11	5.8		5.1	5.7
20	5-40	17.0	1.7	2.9	1.4	2.5	1.6	15	4.0		1.5	3.1
21	9-50	24.0	3.6	0	1.4	2.5	4.9	7.4	0.6		3.8	3.2
AUG.												
12	5-50	16.8	1.5		1.4	1.2	1.5	26	4.6			2.6
13	5-0	18.3	1.5	0	0	0	0	0	1.2		0	1.0

FIG. 6.—Transpiration Curves, Series C., Table IX.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right temperature in degrees F. The temperature curve is dotted.

TABLE IX.—TRANSPIRATION RECORDS.

SERIES C. SUMMER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920. Dec.	Time from.	No. of Hours	Register Numbers of Plants. 17	22	29	42	47	62	66	75
15	10–20	8.0	50	65	74	69	118	148	142	92
20	10–30	3.0	50	94	124	81	331	200	74	170
21	8–5	3.0	55	63	85	78	169	218	160	107
,,	11–10	2.0	53	77	88	119	250	270	137	126
23	8–50	2.0	70	63	153	186	264	226	102	135
,,	10–50	1.0	99	90	153	186	346	226	102	135
,,	11–50	1.0	95	90	153	186	390	226	102	170
,,	12–50	2.0	105	90	167	186	485	226	102	170
,,	2–50	2.0	68	90	167	186	405	226	102	135
,,	4–50	1.0	21	63	104	186	228	226	102	85
24	8–50	2.0		58	121	183	250			113
,,	10–50	1.0	86	58	121	183	280	304	240	148
,,	11–50	1.0	57	58	121	183	213	304	240	126
,,	12–50	2.0	76	63	135	219	206	261	228	142
,,	2–50	1.0	69	63	135	219	220	261	228	35
,,	3–50	1.0	57	63	135	214	242	261	228	92
30	9–30	1.0	42				88			38
,,	10–30	1.0	63				132			47
,,	11–30	1.0	54				169			63
,,	12–30	1.0	62				198			31
,,	1–30	2.0	64				92			57
,,	3–0	1.0	53				22			31
31	9–30	2.0		18	77	143			114	
,,	11–30	2.0		22	77	147			114	
,,	1–30	2.0		18	67	159			154	
FEB. 1921.										
10	11–20	2.0	71	47	66					72
,,	1–20	1.0	59	36	64					58
,,	2–20	1.0	55	49	76					80
,,	3–20	1.0	42	36	85					69
11	10–40	2.0–	27	18	89					13
,,	12–40	2.0–	27	45	74					16
,,	2–40	1.0	16	36						31
DEC. 1920.							DAY.	SHADE.		
30	9–30	2.0		13	40	36				
,,	11–30	3.5		13	54	60				
,,	3–0	1.0		9	59	71				
31	9–30	2.0	34				88			25
,,	11–30	2.0	41				96			38
,,	2–30	2.0	31				81			10
DEC. 1920.							NIGHT.			
20	1–30	18.5	10	14	18	17	59			25
JAN. 1921.										
4	8–40	2.0	2	4	0	6	0		85	19
FEB.									22	35
10	3–45	18.3		9						

For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

No. 78. Grevillea robusta (Silky Oak).

Description.—Bentham, Vol. V., p. 459 (4).

Epidermis.—It was difficult to remove, as that on the under side was so thin. It did not stain very well with gentian-violet.

Area.—Each leaf was traced on paper and the area found in the usual way. Table I., p. 184.

Stomata.—On the under side only. The venules are so fine that they do not interfere with the arrangement of the stomata. The highest records were 240, 230, 220, and 200 per sq. mm., the average being 180 per sq. mm. The pores are small compared with the size of the guard cells. The stomata vary little in size, the average being 36 x 31 micra. The subsidiary cells are similar to those of No. 52. Plate XVII., No. 78; Table XI., p. 226.

Glands.—There are a few scattered over the upper surface.

Hairs.—Are very fine and thread-like. They are more numerous along the veins on the upper side, but are distributed fairly evenly over the whole of the under surface.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 226; Fig. 4, p. 205.

Apparently, No. 78 was too large for the pot it was in, and the water supply was inadequate for a day of high temperatures. On 24/12/20, some of the young leaves shrivelled and the larger ones wilted. With an adequate water supply, the transpiration curve followed the rise in temperature, as shown by the records for 30/12/20 and 10/2/21, and its transpiration rate was very high.

No. 81. Hakea gibbosa (Rock Hakea).

Description.—Bentham, Vol. V., p. 513 (4).

The leaves feel leathery and this is due partly to the fact that the epidermis is very thick. It consists of one layer of deep thick-walled cells, the cuticle being much thicker than the inner wall. The leaf is centric in structure, and beneath the epidermis, two layers of palisade cells surround the medullary tissue, which consists mainly of thick-walled cells.

Epidermis.—This was removed similarly to that of Nos. 13 and 17. It stained well with gentian-violet.

Area.—The complete epidermis of a leaf was mounted in glycerine and measured, the average circumference being 3.6 mm. The leaves of each branch were counted and measured against ten types of known lengths, varying from 1.0 cm. to 6.5 cm. On 10/8/20, there were 399 leaves; and of these 63 were 4.1 cm.; 103 were 3.9 cm.; 55 were 3.6 cm.; and 65 were 2.7 cm. in length. On 7/1/21, there were 874 leaves with an area of 1051 sq. cm.

Stomata.—The stomata, as a rule, are arranged evenly over the whole surface, with the long axes of the pores parallel to each other and also to the long axis of the leaf; but, occasionally, clusters are found at the apex. As mentioned above, the epidermal cells have great depth. The guard cells, with the subsidiary cells, have not

one-fourth of their depth, hence, the stomata appear depressed almost to the level of the inner surface of the epidermis; and the walls of the epidermal cells surrounding the stomata form a funnel-shaped respiratory cavity above the stomata. Plate XVIII., No. 81 (b). The narrow end of this chamber projects slightly above the outer surface of the epidermis. The highest record was 100 stomata per sq. mm., but the average was 70 per sq. mm. They are uniform in size, being 52 x 36 micra. There is a pair of small subsidiary cells with their long axes parallel to that of the pore. Plate XVII., Nos. 81 and 81 (a); Table XI., p. 226.

Hairs.—Are absent from the adult leaves, but the juvenile leaves are closely set with fine, slender hairs, which give them a silky appearance.

Glands.—Absent.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 226; Figs. 1 and 5, pp. 196 and 213.

The highest summer records were 252 on 23/12/20 and 253 on 24/12/20. The second day's results were erratic, but the transpiration curve rose to practically the same maximum on both days. The thrashing by the wind might have affected it at first, but it made much the same curve on both days. Apparently a breeze suits it, as it made a similar curve on 30/12/20. It was used on the transpiration balance from 2/2/21 to 7/2/21, both the plant and the thermometer, being in the tower. Fig. 5, p. 213.

At the higher temperatures the transpiration curve almost coincides with the temperature curve, but transpiration was not vigorous day nor night.

The number of stomata is low—70 per sq. mm.—but they are large, though well protected from the wind, and the transpiration rate was low when there was very little wind.

No. 82. Banksia serrata (Saw Banksia).

Description.—Bentham, Vol. V., p. 555 (4); Maiden, Vol. IV., p. 17 (28).

Epidermis.—This is formed of a layer of thick-walled, narrow, but deep cells, the cuticle of which is very much thickened. The epidermis, on the under side, is only .3 to .5 as deep as that on the upper side, but the walls of the cells are very thick.

Hypoderm is developed on both sides of the leaf and consists of one layer of cells about the same size as the corresponding epidermal cells. There is a great amount of sclerenchymatous tissue in the leaf, for all vascular bundles or veins are accompanied by this tissue, and even with the smaller parallel veins it forms vertical transcurrent plates reaching as far as the epidermis on either side and apparently dividing the leaf into compartments of which these plates form the walls. On the upper side of the leaf there is one, sometimes two, layers of palisade cells; and, sometimes, small patches of palisade cells may be found on the under side of the leaf.

Further, the stomata are not distributed evenly over the surface of the epidermis, as is the general rule, but are congregated into pits. They are closely packed on the sides and the floors of these pits, the walls of which are also lined with fine hairs (cf. Hamilton (21)).

Area.—The area of the leaves was found in the usual way. Table I., p. 184.

Pits.—There are no stomata on the upper surface. The under surface of the leaf is covered with pits which average about 14 per sq. mm. These pits are wide open, but the mouth is usually a little narrower than the base (Ampulliform, according to Mohl. Solereder, p. 711 (40)). The pits vary a good deal in form, and some are single depressions, while others have a single large opening, but soon divide into 2 or 4 smaller pits. The depth of the pits is from .3 to .5 of the thickness of the leaves. The hairs line the ridges and inner walls of the compound pits as well as the outer walls. Plate XVIII., Nos. 82, 82 (c).

Stomata.—To estimate the number of stomata in the pits, series of both horizontal and vertical sections of the leaf were cut, mounted, and examined. Results of the examination of the pits in a series of 11 horizontal sections:

	Pits.		Hairs.	Stomata.		
	Pit	Size in mm. L × B × D		Sides	Base	Total
*	1.	.368 × .144 × .100	57	28	19	47
*	2.	.210 × .116 × .080	44	22	13	35
*	3.	.304 × .60 × .110	69	38	28	66
	4.	.224 × .128 × .114	52	13	16	29
	5.	.224 × .112 × .110	32	14	12	26
	6.	.160 × .096 × .060	20	11	18	29
†	7.	.224 × .096 × .070	23	15	8	23
8a	8.	.208 × .096 × .100	42	10	13	23
8a	9.	.176 × .096 × .100	39	10	10	20
8a	10.	.176 × .112 × .100	32	11	12	23
8a	11.	.144 × .128 × .100	28	14	6	20
	Total for 15 pits		438	186	155	341
	Average per pit		30	12	10	23

* Signifies divided into two pits 4 micra from the surface.

† Signifies divided into two shallow pits. This occurs when the wall of sclerenchyma accompanying a strand passes above the pit.

8 (a) was a pit with a single opening which divided into 4 pits 2 micra from the surface.

The study of these sections showed that there were few stomata around the upper edge of the pits, that there were two, sometimes

three, rows of stomata round the walls of the pits; and that they were practically touching end to end, that the bottoms of the pits were almost covered with stomata which were arranged in such a way that the guard cells could not interfere with each other.

Results of the examination of a series of vertical sections through the leaf:

	V.S. of Pits.			Stomata.				Hairs.		
No.	L	B	D	End	Side	Base	Total	Side	Base	Total
	mm.	mm.	mm.							
1.	.256 ×	.100 ×	.080	18	4	11	33	11	14	25
2.	.192 ×	.100 ×	.080	7	8	7	22	12	8	20
3.	.090 ×	.062 ×	.062	9	4	4	17	8	3	11
4.	.120 ×	.112 ×	.080	7	10	5	22	13	5	18
5.	.170 ×	.144 ×	.096	13	6	12	31	16	10	26
6 × 2.	.210 ×	.192 ×	.096	6	11	20	37	23	16	39
	Total for the seven pits						162			139
	Average per pit - - - -						23			20

A study of these results showed that the hairs were fairly evenly distributed in depth, that there was often a raised portion in the middle of the pit with a number of hairs on it, and that there were usually from 2 to 5 hairs growing on the base of the pit.

TABLE X.—TRANSPIRATION RECORDS.

Series D. SUMMER. Day. In Sun.

Records of Weighings in grammes per sq. metre per hour.

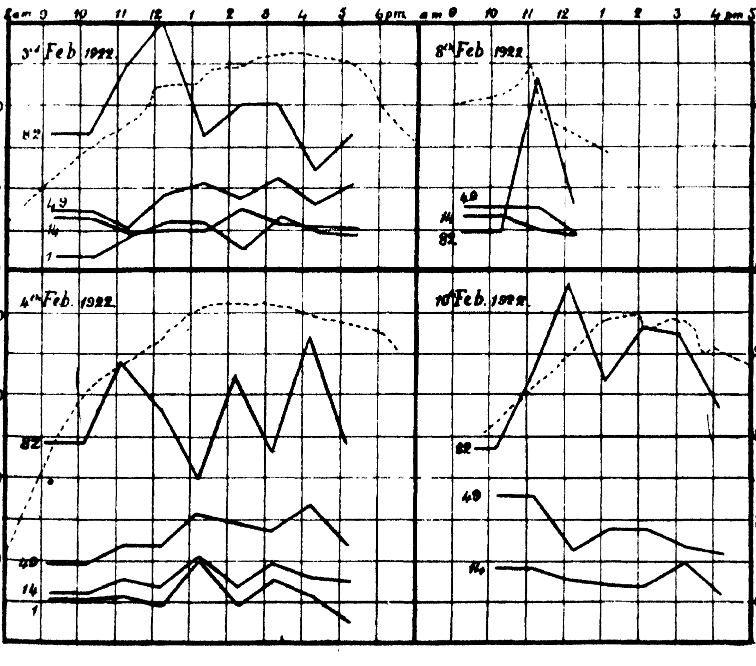
1922. Feb.	Time From.	No. of Hours.	Register Numbers of Plants. 1	14	49	82	X
3	9–15	1	17	64	72	162	
	10–15	1	43	46	53	243	422
	11–15	1	60	50	91	300	790
	12–15	1	56	49	104	162	790
	1–15	1	29	73	88	200	1006
	2–15	1	65	56	112	200	1034
	3–15	1	46	53	80	120	1025
	4–15	1	43	53	101	162	1006
4	9–9	1	51	58	99	243	516
	10–9	1	56	79	120	340	1175
	11–9	1	46	68	117	284	1160
	12–9	1	102	106	115	200	1270
	1–9	1	39	68	144	324	1310
	2–9	1	76	99	136	234	1840
	3–9	1	54	81	168	372	1500
	4–9	1	26	76	120	243	1220

TABLE X. (*Continued*).

1922. Feb.	Time From.	No. of Hours	Register Numbers of Plants. 1	11	49	82	X
8	9–15	1		68	80	49	291
	10–15	1		53	80	235	516
	11–15	1		45	48	81	330
10	11–7	1		91	176	316	583
	12–7	1		79	112	430	1050
	1–7	1		71	136	316	1240
	2–7	1		70	136	380	1370
	3–7	1		99	115	372	1320
	4–7	1		61	109	284	940

X = Evaporation from free surface of water.

FIG. 7.—Transpiration Curves, Series D, Table X.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right temperature in degrees F. The temperature curve is dotted.

The average number of stomata coincided by the two methods, but the number of hairs differed a great deal. This was probably due to the fact that in the examples taken by the first method

there were 5 compound pits, and the number of hairs was then higher as they develop on the ridges separating the pits.

The highest record for a single pit was 33 stomata, the average number being 23 per pit. The average number of hairs may be taken as 25 per pit.

When the under surface is viewed from the outside, the pits seem to be a fair distance apart, but on examining the horizontal sections it is seen that the whole of the under surface is taken up with the system of pits, the boundaries between them being formed by vessels and fibres. Plate XVIII., No. 82. Each pit is surrounded by very open spongy mesophyll, bounded by and separated from, other pits by these vessels and fibres. The average number of pits per sq. mm. is 14. As mentioned above, the stomata are packed closely together in the pits, the average per pit being 23. Hence, the number of stomata per sq. mm. will be 322.

The guard cells stain well with gentian-violet, and look very dark, but they always show as two disconnected masses. The reason for this is understood when a transverse vertical section of the stoma is studied, for it will be seen that the guard cells have comparatively great depth, that they project into the pit, and that the upper or outer half of the guard cell is not stained, because it is cuticularised; so that even in the walls of the pits the armour of the leaf is continued. Plate XVIII., Nos. 82 (a), 82 (b), 82 (d). The size of the stomata is uniform, being 31 x 26 micra. The subsidiary cells are small and the long axes lie parallel to that of the pore.

Glands.—Absent.

Hairs.—Are unicellular, the basal part is thick-walled and cylindrical, terminating in a fine, hair-like thread. They average between 20 and 30 in a pit, and, as they project from the pits, they give the under surface of the leaf its characteristic hoary appearance. They prevent dust and moisture from entering the pits.

Transpiration experiments.—See Tables X. and XI., pp. 220 and 226; Fig. 7, p. 221.

There were no winter records. The highest summer records were 300 on 3/2/22, 372 on 4/2/22, and 430 on 10/2/22. Nos. 49, 14, and 1 were weighed with No. 82 for purposes of comparison. Although there were no great changes in temperature on the above dates, the transpiration curve of No. 82 showed great variation, but those of Nos. 49, 14, and 1 showed almost similar variations, but in much less degree.

The transpiration rate is a fairly high one, and responds readily to increase of temperature.

No. 83. Coprosma Baueri.

Description.—Kirk (23).

Epidermis.—This was easily removed, as the cuticle, especially of the upper surface, is very thick and tough. It did not stain well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—They are distributed evenly over the whole under surface. There are none on the upper surface. On a very young leaf the average per sq. mm. was 740. On full grown leaves, the highest record was 660, the average being 400 per sq. mm. The most common size is 23 x 13 micra, but there are usually 10 to 20% of larger ones, measuring 31 x 21 micra. There is a pair of subsidiary cells with the long axes lying parallel to that of the pore. Plate XVIII., No. 83; Table XI., p. 226.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables IV., V., XI., pp. 204, 205, and 226; Fig. 4, p. 205.

On 24/12/20, all the leaves were wilting about 3 p.m., and their margins were curling under. After 24/12/20, many of the leaves became yellow and fell off.

No. 86. Prostanthera lasiantha (Christmas Bush).

Description.—Bentham, Vol. V., p. 93 (4).

Epidermis.—It required great care to remove the epidermis entire, as it is thin. It stained fairly well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—Are found on the under side only, and are evenly distributed over the whole surface. The highest record was 370, the average being 260 per sq. mm. The guard cells are large, but the pore is relatively small. The average size of the stomata is 29 x 21 micra. There are usually two subsidiary cells lying to the right and left of the stoma with their long axes at right angles to that of the pore.

Glands and Hairs.—The whole of both surfaces of the leaf are covered with evenly arranged glandular hairs, averaging from 15 to 20 per sq. mm. They are spherical in form. and the head is divided, by vertical walls, into 16 sections (cf. Solereder, p. 636 (40)). Plate XVIII., Nos. 86 and 86 (a).

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 226; Fig. 6, p. 215.

Few weighings were made with No. 86, and, after 24/12/20, it was useless for experiments, as the leaves turned yellow and died.

No. 87. Veronica Dieffenbachii.

Description.—Cheesman, p. 500 (10).

Epidermis.—It was easily removed, as it is thick and tough, the upper being much thicker than the under. It did not stain very well with gentian-violet.

Area.—The areas of 39 leaves were measured and the total taken as a standard. Table I., p. 184.

Stomata.—There are none on the upper surface, but they are distributed evenly over the whole of the under surface, except where a broad band of thick-walled cells marks the position of the midrib. The highest record was 800, the average being 600 per sq. mm. They are fairly even in size, the average being 31 x 23 micra. There

are no definite subsidiary cells. Sometimes 2, 3, or 4 cells are associated with a stoma. Plate XVII., No. 87; Table XI., p. 226.

Glands and Hairs.—The whole of the under surface on which stomata are developed, is also dotted fairly regularly with glandular hairs, averaging between 20 and 30 per sq. mm. They look like small toy balloons. The stalk is comparatively short and stout. The head is almost circular in outline, its diameter being a little shorter than the length of the stalk; and it is divided into two sections by a vertical wall. Plate XVIII., No. 87.

Transpiration experiments.—See Tables VI., VII., XI., pp. 204, 205, and 226; Fig. 4, p. 205.

On 24/12/20, the wind scorched the leaves and they began to turn yellow and curl. Water was added at 2.45 p.m., and, soon after, the transpiration rate rose suddenly.

No. 88. Myoporum insulare (Boobialla).

Description.—F. v. M (34).

Epidermis.—The epidermis was easily removed and cleared from the underlying tissues, as it is very strong and much thickened on both sides of the leaf. The structure of the leaf is uniform, consisting of seven or eight rows of cells more or less rectangular to square in outline, and varying little in size or shape. The veins run through the middle of the lamina and so do not approach the epidermis; hence, the stomata are developed over the whole of the surface, except on the midrib. There are few secretory cavities. The epidermis did not stain well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—They are evenly distributed on both sides of the leaf. The highest record was 110, the average being 80 per sq. mm. for both sides of the leaf.

In vertical transverse section, the guard cells have the appearance of a pair of birds facing each other. The upper and outer parts of the guard cells are cuticularised, and project a little above the surface of the epidermis. The shape of the guard cells causes the formation of a vestibule before the inner respiratory chamber is reached. The stomata are uniform in size, the average being 44 x 31 micra. The subsidiary cells consist of three irregularly shaped cells, grouped round the stoma. Plate XVIII., No. 88; Table XI., p. 226.

Glands and Hairs.—Glandular hairs are numerous on both surfaces of the leaf, being more numerous along the midrib, where they may number from 5 to 10 per sq. mm., but the average number for the rest of the leaf is 2 to 3 per sq. mm. They have short hollow stalks, and the disc-like head is divided by vertical walls into 8 or 10 compartments. The bases of the hairs are depressed slightly below the epidermis, and their heads are level with, or project slightly above, the surface of the epidermis. Plate XVIII., No. 88 (a).

Transpiration experiments.—See Tables IV., V., XI., pp. 194, 195, and 226; Fig. 6, p. 215.

TABLE XI.—RECORDS OF AVERAGE TRANSPIRATION RATES AND STOMATA.

Pl.—Register numbers of plants.

W.—Average Winter Transpiration Rates, 1920.

23(s), 24(s), 30(s), 30(d), 31(s), 31(d)—Average transpiration rates for these dates in December, 1920. (s) = in sun. (d) = in shade.

N.—Average transpiration rates between 8 p.m. and 10 p.m. on 4/1/21. Temperature at 9 p.m., 67° F. Wet bulb, 61.20° F. at 10 p.m 63° F. Wet bulb 58° F.

A.—Average number of stomata per sq. mm. of transpiring surface.

B.—Length of stomata in micra.

C.—Breadth of stomata in micra.

D.—Average transpiration in grammes per million stomata per hour for 8 hours on 23/12/20.

Pl	W.	23(s)	24(s)	30(s)	30(d)	31(s)	31(d)	N	A	B	C	D	Pl
												GRMS.	
1	33	151	177	115			77	14	320	24	19	4.1	1
6	43	213	201		42	134		20	310	21	18	5.4	6
6										30	26		6
13	43	368	424	246			191	30	500	31	18	5.9	13
14	28	135	152	128			81	23	120	31	25	9.0	14
17	26	85	70	57			36	1	192	23	18	3.5	17
19	34	328	324		107	257		10	183	36	16	14.3	19
22	51	83	60		12	19		2	100	31	26	6.7	22
26	38	172	153	123			42	4	145	31	21	9.5	26
27	33	50	75	55			36	2	155	35	27	2.6	27
28									155			3.4	28
29	50	150	133		51	74		0	158	27	19	8.0	29
31	40	140	141	110			76	4	200	29	16	5.6	31
33									250	23	20	3.3	33
34									220				34
35	34	42	25	65			48	2	220	26	18	1.5	35
40	72								250	26	23		40
41	72	186	172	91			63	0	250			6.0	41
42	46					150			155	26	18		42
43		186	211		55			3	155			9.7	43
44	88								250	29	21		44
47	97	380	233	133			88	0	110	42	34	28.0	47
49	34	230	250	155			120	0	230	31	26	8.0	49
50	49								540	21	18		50
52	50	191	183	137			79		210 ro.	31	23	7.3	52
53	57								210 sm.	33	26		53
59	86	502	640	375			235	5	610 un.	26	21	6.6	59
59									up.	42	31		59
61	59								610				61
62	57								280	26	21		62
63	60			185		139			240 un.	23	18		63
64	68	207	212					12	240 up.	29	23	7.0	64
65	60								240 ad.	65	55		65
66	30				57	127		42	240				66
67	39								132 un.	52	47		67
67									up.	70	65		67
68	47	169	180	121			75	8	220 un.	29	18	6.1	68

TABLE XI. (*Continued*).

Pl	W.	23(s)	24(s)	30(s)	30(d)	31(s)	31(d)	N	A		B	C	D	Pl
68										up.	31	26		68
69	85	490	562		161	357		37	270		31	23	14.0	69
71	31	132	135	114			78	5	310	un.	18	16	3.4	71
71										up.	21	16		71
71										ad.	20	15		71
75	26	148	114	46			24	9	240		23	21	0.5	75
78	16	172	170	195			105	8	180		36	31	7.7	78
79	50								180				14.4	79
81	35	217	192	134			53	6	70		52	36	25.0	81
82									322		31	26	9.2	82
83	67	349	225	132			66	0	480		26	21	5.9	83
86	52	275	140						260		29	21	9.0	86
87	35	275	174						600		31	23	3.2	87
88	26	157	187		38	149		6	80		14	31	15.7	88

ro. =rough ; sm. =smooth ; un. =under ; up. =upper ; ad. =adult.

For temperature records see Table II., p, 185.

For wind velocity records see Table III., p. 186.

(9) DISCUSSION ON TRANSPIRATION AND THE RESULTS OF EXPERIMENTS.

Transpiration and the External Factors affecting it.

Temperature.—The lowest temperature recorded during days on which experiments were being conducted was 32° F. on 16/7/20, and this was the minimum temperature for the winter in the system garden. The average winter transpiration rate in the sun was very low as compared with the high summer rates. The plants with the lowest winter transpiration rates were Nos. 17, 75, and 88, each with a transpiration rate of 26; and No. 14, with 28. No. 47 had the highest transpiration rate, which was 97. The Acacias (Nos. 17-35) averaged 40, the Eucalypts (Nos. 52-71) 56, and No. 13, 43. The winter transpiration rate in the shade was exceedingly low, and that at night almost negligible. It is not intended to imply that these low rates were due to temperature only. A glance at Table II., p. 185 will show that the relative humidity was very high in winter as compared with the summer rates, e.g., 75% on 21/7/20 at 3 p.m., and 17% on 23/12/20 at 3 p.m., and this is a very important factor in regulating transpiration.

To give a clearer idea of the effects of the high summer temperatures on the transpiration rate, some of the data has been graphed (Figs. 1, 4, 6, and 7) Fortunately, it was possible to make observations on a day like 23/12/20, when the temperature rose steadily to 108° F., with only a good breeze blowing, and to compare them with those made on the following day, when the temperature rose to the same height, but with a fierce north wind blowing. It will be seen that in almost every case, the transpiration curve followed the temperature curve in proportion to the transpiration rate of the plant.

Nos. 1 and 27 (Fig. 1, p. 196), No. 78 (Fig. 4, p. 205), and No. 41 (Fig. 6, p. 215) did not follow the general rule on account of insufficient water supply.

No. 1 showed wilting of the young leaves, but soon recovered when given water. The transpiration curve of No. 41 began to decline at about 12.45, and the upper leaves began to wilt at 3.30 p.m., but when water was added they soon recovered their turgidity. Wilting usually took place almost as soon as the transpiration rate began to decline, but occasionally it did not show until much later, as in the case of No. 41.

In all records it will be noted that there are fluctuations which apparently cannot be accounted for. This has been the experience of all observers whatever methods they were using.

On 24/12/20, when the conditions were similar to those of the previous day, except that a strong wind was blowing, the transpiration curves were not so regular, for, except in a few cases, transpiration was disorganized to varying extents until the wind became less violent.

The highest transpiration records were made on 24/12/20, and were as follow:

No. 59	750	between 12 and 2 p.m.
No. 69	640	„ 12 „ 2 p.m.
No. 13	525	„ 2 „ 3 p.m.

The lowest records for these two days of high temperatures were as follow:

No. 35	45	on 23/12/20	(Average for the day)
No 22	60	„ 24/12/20	„ „
No. 17	70	„ 24/12/20	„ „
No. 14	135	„ 23/12/20	„ „

The transpiration increased very rapidly when the temperature rose above the normal, and the records show that the transpiration rates at the higher temperatures (100° to 108° F.) were from .3 to .6 times greater than those at the lower temperatures (90° to 100° F.).

Further, on 10/2/21 and on 11/2/21, the transpiration curves followed approximately the temperature curve until the water supply became inadequate.

The curves from the transpiration balance experiments (Figs. 2, 3, 5) showed also that a rise in temperature caused a rise in the transpiration rate in proportion to the rise in temperature, and according to the characteristics of the plant.

Shade.—On 31/12/20, the majority of the plants were kept in the shade all day, but, though the temperature rose 6° or 7° F. higher than on the previous day, the transpiration rates were very much lower.

Night.—In winter, transpiration during the night was practically nil, but, with the higher summer temperatures, the transpiration at night was greatly increased. This can be seen from the

transpiration balance experiments and from the records of weighings made on 4/1/21 from 8 p.m. to 10 p.m. (Tables IV. to XI.).

The maximum transpiration for the day falls between 12 noon and 3 p.m.; at higher temperatures, usually after 2 p.m., and nearer 3 p.m.

The minimum transpiration rate at night usually falls between 1 a.m. and 2 a.m.; but, as shown in the curve of No. 71 (Fig. 3, p. 201) it may occur much later when conditions are abnormal.

The maximum transpiration rate, as a rule, is reached before the maximum temperature; and, soon after the maximum temperature is reached, that is, soon after 3 p.m., the transpiration curve falls very quickly; but this steep fall cannot altogether be due to the fall in temperature, as it declines more quickly than the fall in temperature. The above results agree with those of the majority of observers.

Light.—Light has a very definite effect on the transpiration rate. It has been observed that, at night, the transpiration rate, normally, is exceedingly low.

Darwin (13), by experiment on the light factor, came to the conclusion that the direct effect of light was considerable, and the transpiration rate, irrespective of the influence of the stomatal change, was as much as 36% greater in light than in darkness.

In summer, even with a minimum temperature for the night between 70° and 80° F., the transpiration rate for most plants is very low, and not comparable with that in daylight at the same temperature.

In the shade, even at temperatures between 70° and 90° F., the transpiration rate is less than .5, and in many cases only .3 of what it is in sunlight at the same temperature.

Time did not permit of any direct observations on the opening of the stomata, but the very steep rise of the transpiration curves and their sudden fall, as shown in the graphs for 23/12/20 and 24/12/20, seem to indicate that the maximum opening was reached very early in the morning, and that closure (not total), at least, in plants with high transpiration rates and at high temperatures, takes place between 4 and 5 p.m. cf. Lloyd, p. 96-97(25) and Darwin (14).

Light, or rather, intense light also influences transpiration indirectly by causing plants that are exposed to it to modify the structure of their leaves and their position with regard to the rays of the sun. cf. Bergen (5), Schimper, p. 9 (39), Ewart, p. 447 (16).

Only four plants showed active movement of leaves in response to the intensity of light. These were Nos. 40, 45, 47, 69. The leaves of Nos. 40, 45, 47 placed themselves almost parallel to the stems. The margins of the leaves of No. 69 curled upwards and inwards. This change of position apparently did not affect the transpiration rate. Schimper, p. 9 (39), mentions that "Xerophytes with pinnate leaves have the power of automatically adjusting the transpiring leaf surface, and that the fact that they thrive alongside aphyllous plants in the driest regions proves how perfectly this arrangement works."

Acacia Baileyana (No. 35) is apparently an exception to this rule, for its bipinnate leaves do not close on to one another, nor has it special power of adjusting its leaves, yet it had the lowest transpiration rate of all the plants studied. The rest of the Acacias (Nos. 17 to 33) have phyllodia which are held, more or less, in a vertical position and in such a manner that their surfaces do not receive the full force of the sun's rays.

The Eucalypts (Nos. 52-71) were all seedlings or very young plants and their leaves were not always placed parallel to the incident rays of the midday sun, but they have other means of protection and usually they would be more or less shaded in their natural habitat. The adult leaves of most of them are placed, more or less, in the vertical position with the edges turned towards the source of light. Again, Renner (70, 71) has shown that the rate of evaporation from vertical surfaces was not appreciably affected by other evaporating surfaces if they were more than 2cm. apart; hence, the massing of the adult leaves of the Eucalypts or the phyllodia of the Acacias will not greatly affect the transpiration rate. He also found that the evaporation from a long narrow surface is greater than that of a similarly great, but more isodiametric one. This factor must play an important part in the transpiration rate of the narrow-leaved and phyllodinous plants, as compared with the broad-leaved ones.

Wind.—Wind velocities for each day on which experiments were carried out will be found on Table III., p. 186. It has been mentioned above that the wind tends to increase the transpiration rate of a plant; but an examination of the graphs on Figs. 1, 4, and 6, will show that if the velocity of the wind exceeds 15 to 20 m.p.h., the transpiration rate of many plants is disorganized—probably on account of the closing of the stomata, due to the concussion of leaves and branches. Knight, p. 133 (24), found that some stomata are sensitive to the shock produced by handling the leaf. From an examination of the data on Table II., p. 185, it will be seen that conditions, except for wind velocity, were similar on 23/12/20 and 24/12/20. From Table XI., p. 225, it will be seen that about half the plants showed an average increase in the transpiration rate for 24/12/20, as compared with the previous day, while the other half showed a decline. The same effect can be seen by an examination of the records for 8/7/20 and 9/7/20, Table IV., p. 194, and wind records on Table III., p. 186, and temperature records on Table II., p. 185.

On 8/7/20, there was a pleasant breeze averaging from 5 to 7 m.p.h., while on 9/7/20, during the time of the experiments, the wind averaged 20 m.p.h. The temperatures varied little. Nos. 1, 13, 19, 27, 59, 67, 71, 81 showed a loss in the transpiration rate, as compared with that of 8/7/20, while Nos. 14 and 49 showed an increase in the transpiration rate.

A study of the transpiration results for 9/7/20 and 24/12/20 shows that Nos. 19 and 81, both with long, narrow phyllodia or

leaves suffered a lowering of the transpiration rate on very windy days, both in winter and in summer.

It will be noticed that the maximum transpiration rate is generally reached between 1 p.m. and 3 p.m., and that the transpiration curve begins to fall soon after 3 p.m., and, apparently, the rapid increase in relative humidity or decrease in evaporation rate is the main cause of the fall. cf. Schimper, p. 4 (39) and Lloyd, p. 143 (25). The evaporation rate from the free surface of water may be compared with the transpiration of plants in Table X., p. 220. The water surface used had an area of 107 sq. cm., and the surface of the water was kept at about 3 cm. below the upper edge of the vessel (Thomas and Ferguson (41)). The results were reduced to show the amount of evaporation from a sq. metre at the same rate. The figures also help to show the great difference between evaporation from a free surface of water and the transpiration from leaves.

Water supply.—All the plants studied are indigenous to districts in which the average annual rainfall is 15 inches (Nos. 34 and 35) or above 15 inches, but, as will have been noted, they vary greatly in their distribution in regard to latitude, altitude, soil, and aspects.

Altitude.—Sampson and Allen, p. 48 (38), in experimenting on the effects of altitude on transpiration, found that "the light intensity was practically constant, that the relative humidity increased with the altitude, and that the atmospheric pressure decreased." The above results were corroborated by Clements (1), and they show that, other things being equal, an increase in altitude stimulates an increased transpiration. This acceleration is not due to increased light intensity and a lower air humidity, but is due to decreased pressure. cf. Schimper, p. 4 (39). One of the most interesting plants studied came under this heading, namely, No. 68, the habitat of which is confined to a few of the peaks in the Grampians mountains, and it has been shown that it is protected from excessive transpiration in many ways, and in both juvenile and adult stages. Plate XIII. Fig. 2.

Transpiration and Internal Factors affecting it.

Time has not permitted the examination of the internal structure of the leaves, except in a few cases such as Nos. 13, 67, 81, and 82, where it was necessary to section the leaf in order to obtain the correct idea of the structure and number of the stomata.

Stomata.—Brown and Escombe (7 and 8), working with the leaves of *Helianthus*, and Lloyd, p. 32-39 (25), with the leaves of *Fouquieria splendens*, showed that the diffusion capacity from a leaf was six times greater than the transpiration rate. Hence, transpiration rates may not be related within wide limits to the dimensions of the stomata; so that increases and decreases in the transpiration rate may occur without being due to stomatal movements.

Number of stomata.—An examination of Table XI., p. 225, will show that the number of stomata per sq. mm. of transpiring surface

ranges from 70 (No. 81) and 80 (No. 88) to 500 (No. 13), 540 (No. 50), 600 (No. 87), 610 (No. 59), and very few have less than 150 per sq. mm., so that, though the epidermis in many cases is exceedingly thick, adequate arrangements are made for the movements of gases through it; and, where the number of stomata is very high, the transpiration rate is high. The highest records of stomata per sq. mm. are: 1030, 970, 960 on some leaves of Nos. 63 and 64; 740 on some leaves of No. 59.

There are very few records of plants with the number of stomata above 500 per sq. mm., and the average number of stomata of the plants studied is relatively high. cf. Morren (30), Tschirch (42), Kerner and Oliver (22), and others.

Sizes of stomata.– These are tabulated in Table XI., p. 225, and range from 52 x 36 micra (No. 81), 70 x 65 micra (No. 67), to 18 x 16 micra (No. 71). No. 81, with stomata 52 x 36 micra, has only 70 per sq. mm., but its transpiration rate is well above the average.

No. 88, with stomata 44 x 31 micra, has 80 stomata per sq. mm., but its transpiration rate is not quite so high as that of No. 81.

No. 47, with stomata 42 x 34 micra, has 110 stomata per sq. mm. on its small leaves, and its transpiration rate is high.

No. 71, with stomata 18 x 16 micra on the under side and 21 x 16 micra on the upper side, has an average of 310 stomata per sq. mm., but its transpiration rate is comparatively low.

The size of the stomata in the Acacias (Nos. 17 to 35) does not vary much, but the same cannot be said of the Eucalypts (Nos. 52 to 71). Illustrations of the stomata will be found on Plates XIII. to XVIII. The figures bear the register number of the plant they represent.

Stomata and epidermal cells.––Copeland, 359 (12), states: "The size of the stoma usually corresponds somewhat to that of the epidermal cells (Salvinia is a conspicuous exception) and the mechanism of the stoma must be correlated with the size, and the depth, and the thickness of the walls of the neighbouring cells." He shows that this must affect the method by which the guard cells move. Most of the plants studied follow this rule, but exceptions will be found in the adult form of many Eucalypts, e.g., No. 64, (Plate XVI., Nos. 64, 64 (a) and 64 (c); No. 67, (Plates XVI. and XVII., Nos. 67 (b) and 67 (d)) where the stomata are much larger than the epidermal cells; and Nos. 47, 78, and 88 (Plates XV., XVII., and XVIII., respectively) in which the size of the stomata is much less than that of the epidermal cells. In most of the plants studied, there are no special structures for protecting the stomata beyond the cuticularization of the outer edges of the guard cells.

Special protective structures prevent excessive transpiration, but, apparently, do not regulate it.

The plants, having special methods of protecting the stomata, are among the most interesting studied.

Hakea gibbosa (No. 81) has the same type of protection as *H. suaveolens* and *H. cyclocarpa* as figured by Tschirch (42).

Plate XVII., No. 81 and Plate XVIII., No. 81 (b).

Myoporum insulare (No. 88) has the stomata raised above the surface of the epidermis, and, though the leaf appears dorsiventral, the structure of both sides is practically the same.

Casuarina Luehmanni (No. 13), with its slender, stringlike branchlets, armoured with a thick cuticle and strengthened by a very large percentage of sclerenchymatous tissue, with its stomata hidden away in fairly thin-walled grooves, which are protected from the direct action of wind, sun and dust by lines of branched hairs, has a winter transpiration rate about the average; but its summer rate is the third highest of the plants studied. High temperatures and strong winds do not affect this plant so long as it can obtain water, but if the supply runs short the transpiration rate falls and the young shoots wilt, but the old branchlets are able to withstand a reduced water supply, and are ready to continue their work when a supply of water becomes available. The transpiration rate responds quickly to changes in temperature, wind velocity, and water supply. Hence, the plant can make the best use of sudden increases in water supply, especially at high temperatures.

Banksia serrata (No. 82).—The structure has been described by Hamilton (20). This plant has its stomata hidden in a somewhat different manner from No. 13, and, as it lives mainly along the coast, has some of the characteristics of a halophyte (Schimper, pp. 88 and 530-534, Fig. 297 (39)), yet its number of stomata is above the average and its transpiration rate is also above the average; but it does not seem to have the same control over the transpiration rate that No. 13 has.

The Eucalypts formed interesting studies, especially as all specimens experimented with had juvenile leaves, except No. 67.

From seedling to adult stage the leaves take 2 or 3 different forms, and in each stage the number of stomata and their size usually differ, as also does the method of protection. The transpiration rates of Nos. 59 and 69 were above the average, but those of the remainder were about the same as those of the Acacias.

Acacias.—The Acacias vary very little in their external arrangements for transpiration and protection from drought. All of them, except No. 19, favour dry localities, and it will be noted that No. 19 has a high average number of stomata per sq. mm. for an Acacia, and that they are the largest.

Acacia Baileyana, which was the only non-phyllodinous Acacia used, gave the lowest transpiration results.

Ficus macrophylla (No. 14) is one of the best drought resisting forms tested. It has stomata on the under surface only and the number is fairly low (120), but with its thick epidermis varnished on the upper surface, it seems to have good control of its transpiration rate. The high velocity of the wind on 23/12/20 made a greater impression on the transpiration rate than did the high temperature.

Transpiration per million stomata.—On Table XI., p. 225, will be found the average transpiration rate per million stomata per hour for 8 hours of daylight on 23/12/20, and a study of them gives some idea of the effect of the number and size of stomata on the transpiration rates of the plants used.

It is interesting that *Pimelea flava* (No. 47), the plant with the smallest leaves, should have the highest transpiration rate: 28 per million stomata. Its stomata are large, but their number is below the average.

Acacia linearis (No. 19).—The Acacia with the highest average for the species, is the one which favours moist localities.

Hakea gibbosa (No. 81).—*Hakea gibbosa* has the second highest average, which is 25. Its needle-like leaves have large stomata, but the number is much below that of No. 47, and its transpiration rate does not differ much from that of No. 47, except at high temperatures, when that of No. 81 is much lower.

The lowest rates are shown by Nos. 75, 33, 71, and 17, and are 0.5, 3.3, 3.4, and 3.5 respectively. These also have the smallest stomata and the number per sq. mm. is not relatively high.

No. 13, with its great range of transpiration rate from winter to summer, and from low temperatures to high temperatures, has a very low average rate per million stomata, but for the size of the area of its transpiring surface, it has a high number of stomata.

A comparison of the transpiration rates per million stomata with the transpiration rates for the areas, emphasizes the facts that the size of the stomata is an important factor in influencing the number of stomata on leaves and the transpiration rate of plants, although the stomata may not have a very great regulatory effect on the absolute transpiration of the plant.

The size of the stomatal aperture has long been recognised as a factor concerned in the regulation of the rate of transpiration, but the extent to which this regulatory function is shared by the stomata with other internal conditions of the plant has not yet been settled.

It is certain that in plants, especially like those of the Acacias (Nos. 17-35) that there must be some important factor, other than that of the opening and closing of the stomata, regulating the supply of water to the foliage, and so regulating, to a great extent, the transpiration rate.

Probably a study of the structure of the stems or roots of the Australian xerophytic plants may help us to realize more fully the manner in which these plants with their relatively high number of stomata of comparatively large size, are able to overcome the extremes of temperature and of water supply. cf. Cannon (9); Ewart and Rees, p. 97 (5); Farmer (17); Richardson (37).

(10) Conclusions.

The main object of this work was to endeavour to discover whether Australian plants, especially those with xerophytic characters, which, in their native state, are able to thrive under adverse

conditions of temperature and water supply, have any special powers of accommodation, such as a regulatory decrease in transpiration, when exposed to such enormous rises in temperature and evaporation as are caused by the hot north wind. cf. Ewart and Rees (15).

The results of the experiments show that, so long as the available water supply is adequate, the plants have no special powers of accommodation as mentioned above, for, as the temperature rises, the transpiration rate increases to the limit of the transpiring power of the plant for that temperature.

Some plants have their transpiration checked when the velocity of the wind rises to about 20 miles per hour.

The phyllodia of the Acacias, from their shape and position on the plant, their large or comparatively large, number of stomata with the thick cuticle to protect them from intense light, heat, and wind, are perfect transpiring organs, and the plants have a relatively high transpiration rate, yet they are found chiefly on xerophytic plants, indigenous to Australia: with the phyllodia must be associated the leaves of the Eucalypts.

The so-called xerophytic plants of Australia are provided with a high average number of stomata, which enables their transpiration rate to respond quickly to changes of temperature and water supply, and they are well protected by their tough outer coverings, in some cases assisted by glands, from injurious loss of water.

Bibliography.

This contains only the names of publications cited in the text. Extended lists of publications dealing with transpiration will be found in the publications mentioned, and especially those marked with an asterisk (*).

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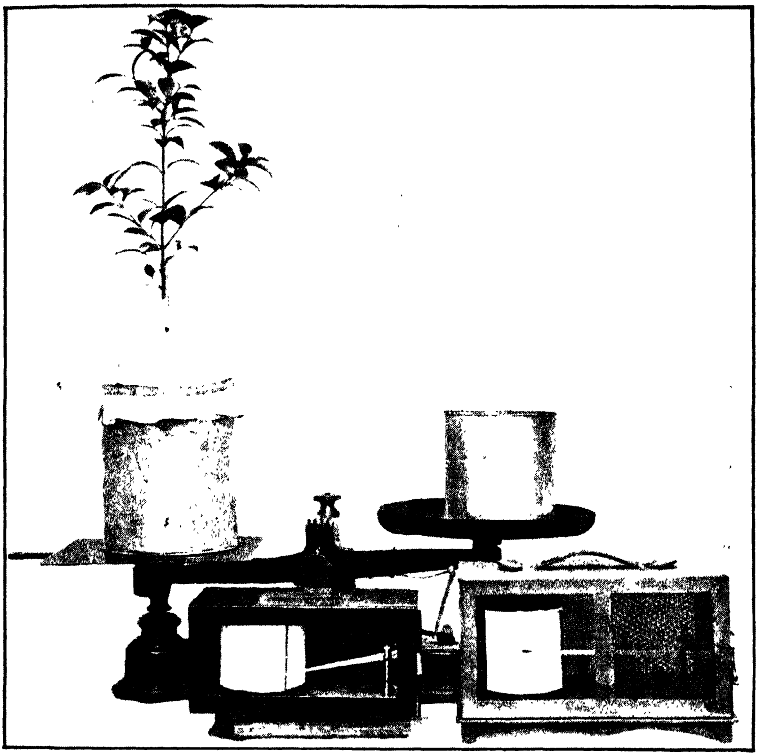
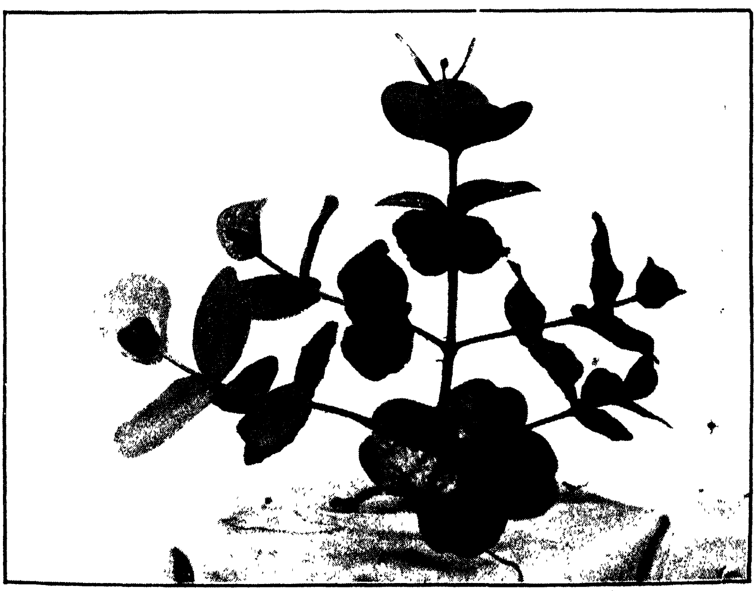
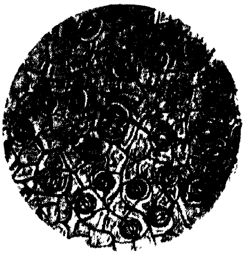


FIG. 1





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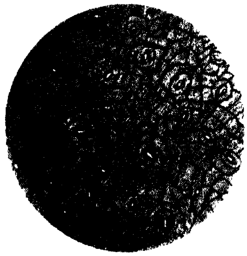

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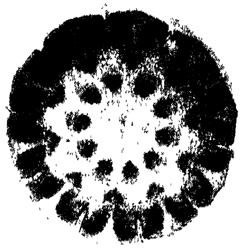


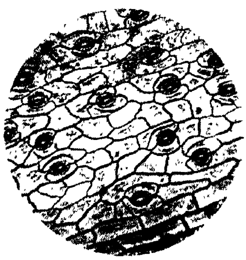
13 × 45

13(a) × 45

13(b) × 110

13(c) × 350

14 × 110



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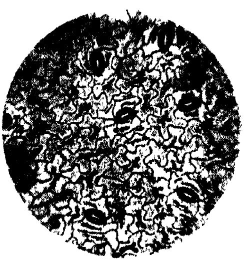

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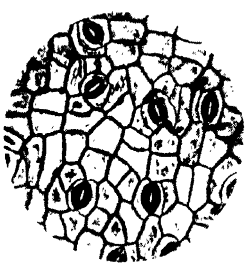

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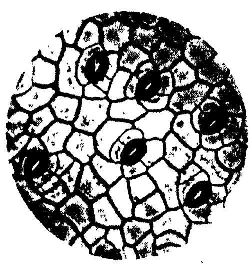

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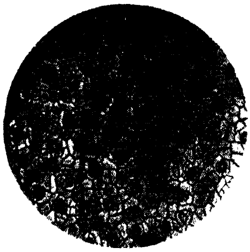

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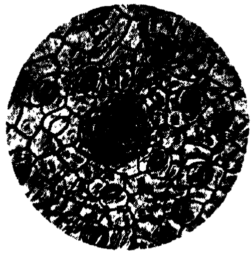

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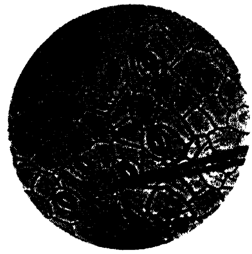

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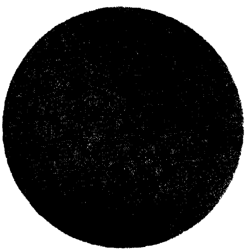

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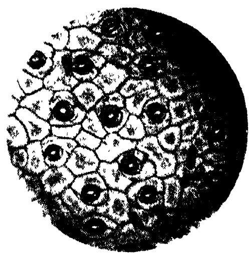

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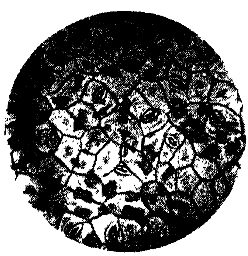

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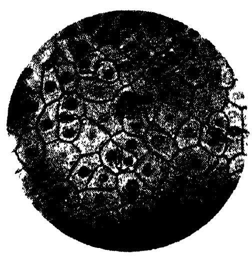

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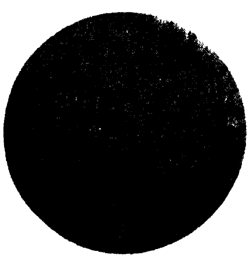

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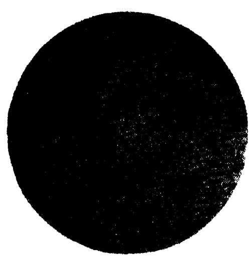

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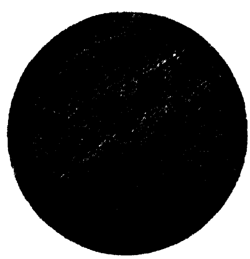

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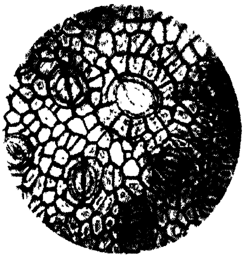

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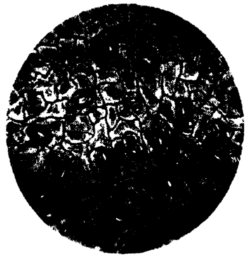

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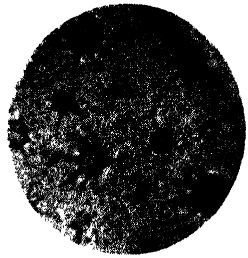
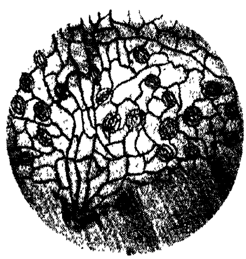


68(a) × 45

69



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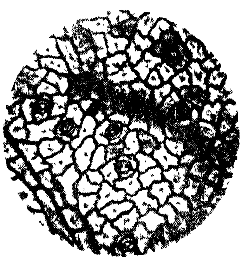

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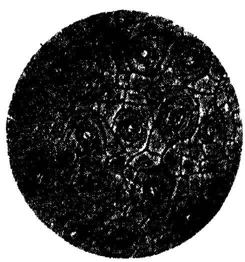

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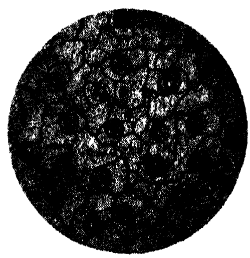

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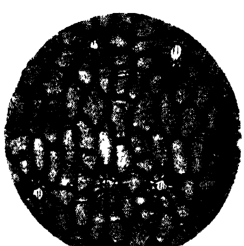

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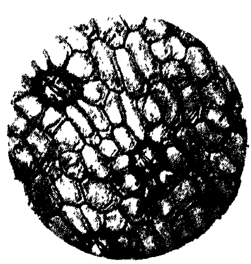

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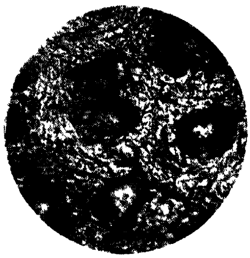
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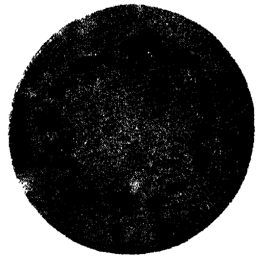
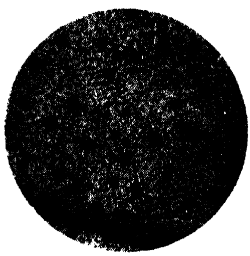

82(a) x 110


82(b)


82(c) x 45


82(d) x 350


83 x 110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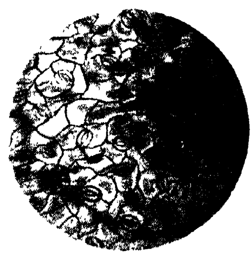
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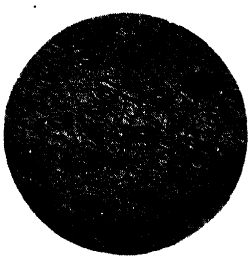
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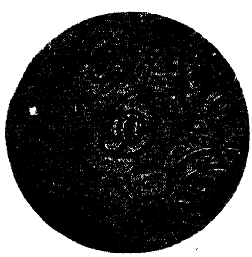
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EXPLANATION OF PLATES.

Plate XIII.

Fig. 1.—Transpiration Balance and Thermograph used in the experiments.

Fig. 2.—Seedling of *Eucalyptus alpina* (No. 68), showing the development of the adult form of leaves on the ends of the longer branches.

Plates XIV. to XVIII.

These contain microphotographs chiefly of the epidermis of the foliage to show stomata, glands, hairs, etc. The numbers on the plates are the register numbers of the plants, and the description of the special structures illustrated will be found under the descriptions of the plants. In reproduction the originals have been reduced 50%.

Plate XIV.

No. 13.—T. S. of an internode of a branchlet. No. 13 (a) view of the walls of a groove, which have been flattened out, showing the longitudinal rows of cells with stomata, and parts of two ridges. No. 13 (b) walls of a groove more highly magnified. No. 13(c) hairs in groove.

Plate XV.

No. 29.—The dark mass in the centre is the base of a hair. No. 31 the apex of a hair is showing. No. 31 (a) shows the arrangement of the hairs. No. 44 shows the bases of two hairs.

PLATE XVI.

No. 52.—Epidermis of younger, rough, hairy leaf. No. 52 (a ditto, showing a gland surrounded by hairs. No. 52 (l epidermis of older, smooth leaf. No. 64 (a) epiderm from an adult leaf. No. 64, epidermis from the under si of a juvenile leaf. No. 64 (b) epidermis from the upp side showing stomata grouped along the midrib, part which can be seen on the right of the figure. No. 64 (epidermis from the under side of a large juvenile lea No. 67, under epidermis. No. 67 (a) upper epidermi showing stomata and large glands. No. 67 (c) V. through leaf to show the slightly sunken stoma.

PLATE XVII.

No. 67 (a).—Part of under epidermis, showing one large gland and number of stomata. No. 68 (a) epidermis, showing a nu ber of glands surrounded by hairs. No. 71, under epide mis. No. 71 (a) a cluster of glands on the under sid No. 71 (b) upper epidermis. No. 71 (c) epidermis fro adult leaf. No. 81, outer, surface of epidermis, showi how the cells of the cuticle form a dome over the stomat No. 81 (a) inner surface of epidermis, showing the gua cells.

PLATE XVIII.

No. 81 (b).—T. S. of leaf, showing part of the epidermis wi a protected stoma. No. 82, under side of lea showing three complete pits. No. 82 (a) H. S. throu pit, showing the wall near the bottom, and the stoma almost touching end to end. No. 82 (b) ditto, showi floor of a pit. No. 82 (c) vertical section through pi No. 82 (d) V.S. through a stoma, base of hair on the rig of guard cells. No. 86, glandular hairs show as da star-like patches. No. 86 (a) epidermis, showing tw glands. No. 87 shows two glandular hairs. No. 88 (a V. S. through a glandular hair.

[Proc. Roy. Soc. Victoria, 36 (N.S.) Pt. II., 1924.]

Art. XII.—*Notes on the "Hairy Cicada" (Tettigarcta crinita).*

By HOWARD ASHTON.

[Read 13th December, 1923.]

Whilst visiting Mount Kosciusko in February, I found emerging a specimen of Cicada which, from the shape of the nymph, I took to be the Gippsland hairy Cicada, not previously recorded in New South Wales. Upon taking it to the hotel, several specimens flew into the room in which I had it, possibly attracted, as some insects are known to be, by emanations of scent which attract the opposite sex. Three were taken in this manner, either in the dusk of the evening, or before dawn.

I concluded that the species could not be uncommon in the district, and set out to find it. I was successful in taking seven specimens, most of them females, in their natural habitat. The pupae emerge upon the "Snow Gums" and stunted "Mountain Ash" of the district. The Cicada, instead of perching on the bare stems of trees and rejoicing in the sunlight, would appear to be nocturnal, for I only saw the insects fly in the dusk, and all the specimens I took were under the bark of trees, hiding like moths.

In the published descriptions of species, it is stated that the opercula, or process covering the musical organs, are obsolete. Dissecting one of the males I could find no trace of any musical organs at all. I do not think they can be regarded as "obsolete." This Cicada, in fact, is very doubtfully a Cicada at all, if the usual classification is to stand. It is far more different in structure than some of the Aphrophorids and Cercopids. Yet, of course, its general form is like that of the Cicadas. Possibly in the future some worker may decide to make a family of this insect, and, really, owing to the immensely dilated pronotum and the absence of musical organs, this would be justified.

I find that Distant's description fails lamentably in respect of colour. The insect is not "all reddish brown" without spots. It is very variable, the body tints being yellow grey with large black streak and patches. In some specimens the frontal "cape" is all black except for a broad greyish stripe down the centre; in others even this stripe is missing; and in others again the black is confined obscurely to the lateral furrows. The colour of the abdomen in almost all cases is black with a tint of chestnut brown on the anterior margins of segments. The only "reddish brown" is in the basal venation and colouration of the hind wings of some specimens, and even there the red is not marked.

I can only conclude that Distant's type must have been an old and stained specimen. I had seen such in the various Museums, and had one in my own collection, all yellowish brown, but the living specimens are entirely different. In some specimens the tegmina are heavily infuscated at the bases and extremities of the apical areas.

Judging from the number of pupal cases I found on trees, the species is not so uncommon as its infrequent appearance in Museum collections would indicate.

ANNUAL REPORT OF THE COUNCIL,

For the Year, 1923.

The Council herewith presents to Members of the Society the Annual Report and Statement of Receipts and Expenditure for the past year.

The following meetings were held:—

March 8th.—Annual Meeting.

The following Office-bearers retired by effluxion of time.—President, F. Wisewould; Vice-Presidents, Professor Laby, Dr. Baldwin; Hon. Secretary, J. A. Kershaw; Hon. Treasurer, E. Kidson; Hon. Librarian, A. S. Kenyon; Members of Council, Professor Osborne, Assoc. Professor Summers, Messrs. A. E. V. Richardson, E. J. Dunn, D. K. Picken.

The following were elected:—

President, F. Wisewould; Vice-Presidents, Professor Laby and Dr. Baldwin; Hon. Treasurer, E. Kidson; Hon. Librarian, A. S. Kenyon; Hon. Secretary, J. A. Kershaw; Members of Council, Professor Osborne, Assoc. Professor Summers, Messrs. A. E. V. Richardson, E. J. Dunn, D. K. Picken.

The Annual Report of the Council, and Financial Statement were read and adopted.

At the close of the Annual Meeting an ordinary meeting was held. Paper: "On Australian Aphodiidae (Coleoptera)." By Arthur M. Lea, F.E.S. Exhibits: A series of exhibits were shown and described by members.

April 12th.—Paper:—"The Trisection and Polysection of an Angle," by Dr. J. W. Penfold. (Communicated by D. K. Picken, M.A.). Exhibits:—Professor W. A. Osborne showed and described a number of exhibits illustrating the culture of the Pueblo Indians of North America.

Dr. W. J. Young was elected a Member, and Dr. H. R. Seddon an Associate.

May 10th.—Lecture:—Dr. W. J. Young delivered a lecture on "Recent Advances in Sugar Chemistry." A series of exhibits were shown, and a discussion followed. Dr. W. J. Penfold and Mr. H. A. Mullet were elected members, and Messrs. John Robert Leslie, E. O. Hercus, M.Sc., and D. H. Adams, B.Ag.Sc., Associates.

June 7th.—A Special Meeting, the first of a series arranged by the Mathematical and Physical Section of the Society was held. Lecture:—Dr. E. J. Hartung delivered a lecture on "The Mount Wilson Solar Observatory." An excellent series of lantern slides were shown in illustration of the lecture.

June 14th.—Papers:—(1) "The Acceleration of Gravity at the Melbourne Observatory" Supplementary Note. By E. F. J. Love, M. A., D.Sc. (2) "Types of Native Boomerangs under Flight." By Sydney Pern, M.R.C.S., L.R.C.P.

Messrs. L. R. East, J. E. Knott, and L. H. Martin, M.Sc., were elected Associates.

July 5th.—A meeting of the Mathematical and Physical section of the Society was held at the Natural Philosophy Lecture Theatre, University. Lecture:—" On the Data and Methods of Aeroplane Design, with some conclusions at to probable developments." By Squadron-Leader F. S. Barnwell, O.B.E., A.F.C. The lecture was illustrated by numerous tables and diagrams, and was followed by a discussion.

July 12th.—Papers:—(1) " Studies on the Comparative Anatomy of the Alimentary Canal of Australian Reptiles." By Wm. Colin Mackenzie, M.D., and W. J. Owen. (2) "A Revision of the Australian Patellidae, Patelloididae, Cocculinidae and Fissurellidae.' By Frederick Chapman, A.L.S., and C. J. Gabriel. (3) " The evidence of Post-Lower Carboniferous Plutonic and Hypabyssal Intrusions into the Grampian Sandstones of Western Victoria." By Ernest W. Skeats, D.Sc., A.R.C.S., F.G.S. (4) " New Australian Micro-Lepidoptera." By A. Jefferis Turner, M.D., F.E.S.

Squadron-Leader L. J. Wackett, R.A.A.F., and Messrs. G. A. Merfield, Eugene Jannsens, B.Sc., and C. H. Wickens were elected Members, and Mr. M. Esserman an Associate.

August 2nd.—A meeting of the Mathematical and Physical Section of the Society was held. Lecture:—Mr. W. Stone delivered a lecture "On Surface Phenomena." The lecturer described an interesting series of experiments made by himself in the investigation of the adhesion of solid bodies. The apparatus used was shown, and his remarks illustrated by an excellent series of lantern slides.

August 9th.—Paper:—" Further Studies in Contagious Bovine Pleuro-Pneumonia." By Dr. G. G. Heslop. (Communicated by Professor H. A. Woodruff.) Lecture:—" The Importance of the Australian Fauna to Medical Science." By Dr. Wm. Colin Mackenzie. The lecture was illustrated by a series of original diagrams and lantern slides.

Flying-Officer H. C. Harrison, A.R.C.S., was elected a Member.

September 13.—Exhibits:—(1) " Example of Mendelian Inheritance in Poultry." By Professor W. E. Agar. (2) " Model Illustrating Polarization of Light by means of Nicol's Prisms." By Assoc. Professor H. S. Summers. (3) " An Unusual Form of Lomaria discolor." By Miss M. Gordon. (4) " Abnormal Leaves of Eucalypts," and " A Section of Balsa Wood." By R. T. Patton, B.Sc. (5) " Samples of Cryptozoon of doubtful Cambrian Age from the McDonnell Range, Central Australia." By Fredk. Chapman.

G. G. Heslop, D.S.O., D.V.Sc., D.V.H., was elected an Associate.

October 4th.—A meeting of the Mathematical and Physical Section of the Society was held in the Natural Philosophy Lecture Theatre, at the University. Lecture:—Professor T. H. Laby, M.A., Sc.D., delivered a lecture on " Recent Developments in X-Rays." The lecture was illustrated by experiments and lantern slides, and was largely attended.

October 11th.—Lecture:—Professor Sir Baldwin Spencer, K.C.M.G., F.R.S., delivered a lecture on "Characteristic Features of Central Australia." The lecture was illustrated with an excellent series of lantern slides and specimens.

Mr. John Laver was elected a Member, Mr. Cedric Deane an Associate.

November 1st.—A meeting of the Mathematical and Physical Section of the Society was held. Lecture:—Mr. E. Kidson, O.B.E., M.Sc., delivered a lecture "On the Norwegian Theory of Cyclones."

November 8th.—Papers:—(1) "Graptolites of Victoria." Part I. By Wm. J. Harris, B.A. (2) "New or Little-known Fossils in the National Museum. Part XXVII. Some Cainozoic Fish Remains, with a Revision of the Group." By Frederick Chapman, A.L.S., and Frank A. Cudmore.

Dr. J. L. Kerr, F.R.S.E., was elected a Member, and Mrs. Marion Rigall Kerr, and Major H. W. Wilson, O.B.E., M.C., B.Sc. Associates.

Messrs. Chapman and Cudmore showed a series of specimens in illustration of their paper, and Mr. E. J. Dunn showed examples of Coorongite from South Australia.

December 6th.—A meeting of the Mathematical and Physical Section of the Society was held. Lecture:—Dr. J. M. Baldwin delivered a lecture on "The Size of Stars." An interesting and comprehensive survey of the subject was given, aided by a series of lantern slides, and was followed by a discussion.

December 13th.—Papers:—(1) "Notes on the Hairy Cicada, *Tettigarcta crinita*, Dist." By Howard Ashton. (2) "The Geology of the Coimaidai Area, with special reference to the Limestone Series." By Arthur L. Coulson, M.Sc. (3) "Studies on the Transpiration of Some Australian Plants, with notes on the structure of their leaves." By H. W. Wilson, O.B.E., M.C., C.d'G., B.Sc.

Dr. E. J. Hartung and Sidney C. Richardson were elected Associates.

During the year, ten Members and fourteen Associates were elected. Two members, and three associates resigned, and one country member, and two associates died.

The Council regrets to record the loss by death of Mr. John Cronin, and Mr. H. R. Hogg, M.A., F.Z.S., and Mr. J. J. Fenton.

John Cronin, who died on the 30th June last, after a long and painful illness, occupied the position of Director of the Melbourne Botanic Gardens for about fourteen years. Joining the Department of Agriculture in 1886 he succeeded Mr. W. B. Luffman as Principal of the School of Horticulture at Burnley in 1908, and the following year succeeded the late Mr. W. R. Guilfoyle as Director of the Botanic Gardens. He specialised in Horticulture and devoted considerable attention to hybridizing and improving garden flowers, and the cultivation of indigenous plants. His knowledge and experience were frequently availed of in the laying out and improving of the public gardens of this State, in which he took a very keen interest. He was elected an Associate of the Society in 1921.

Henry Roughton Hogg, whose death occurred at his residence, St. Helen's Place, London, was a well-known authority on Australian Spiders (Arachnida). During his residence in Victoria he undertook the determination of the Spiders collected on the Horn Expedition to Central Australia, published in 1896, and described a number of new species. Following this, his first published work on the group, he contributed numerous papers to the Proceedings of the Zoological Society, London, Annals and Magazine of Natural History, and other scientific journals. He was elected a Members of this Society in June, 1890 and about ten years later took up his residence permanently in London. He was a Fellow of the Zoological Society of London, and for many years a member of the Field Naturalist's Club of Victoria.

James Jemison Fenton was the son of James Fenton, a doctor of medicine in Manchester, England. He was born in 1856, in Manchester, and was educated at the Scotch College, Melbourne. He joined the Public Service of Victoria in 1874, and was appointed to the Government Statist's Office, to which he was attached until his retirement in March, 1916. He was associated for many years with the preparation of the Victorian Year Book, to which he contributed much valuable matter. He also rendered important assistance to the Government when it was dealing with the question of Federation. He had charge of all work connected with the Victorian Census of 1901, and in later years introduced improvements in the works of the branch which deals with the Registration of Births, Deaths and Marriages. Shortly after his retirement in 1916, he went to London to be near his sons, who were on active service, and while there was engaged for some time on work at the Admiralty. He died in Melbourne early in 1923, leaving a widow, two sons and a daughter. He joined the Society as an Associate in 1910.

The attendances at the Council meetings, were as follow:—

Mr. Kidson, 12; Mr. Wisewould, 11; Mr. Kershaw, 11; Mr. Dunn, 11; Mr. Shephard, 10; Dr. Baldwin, 9; Mr. Chapman, 9; Professor Skeats, 8; Mr. Richardson, 8; Mr. Picken, 8; Professor Osborne, 7; Professor Laby, 6; Assoc. Professor Summers, 6; Mr. Kenyon, 6; Professor Agar, 5; Dr. Green, 5; Mr. Herman, 3; Mr. Gray, 2.

The ordinary meetings continued to be well attended, and though the papers contributed were not as numerous as could be desired, the exhibits were varied and of special interest. Two meetings were devoted to the exhibition of objects in various branches of science which were described and discussed by members. Illustrated lectures of a popular nature on subjects of general interest were delivered by Dr. W. J. Young, Dr. Wm. Colin Mackenzie, and Professor Sir Baldwin Spencer and were largely attended.

With a view to increasing the interest in the Society of workers in Mathematics, Physics, Astronomy and Chemistry, a committee of the Council was appointed to consider and report on the question of forming a section of the Society to deal specially with these sciences.

On the recommendation of the committee the Council decided to form a Mathematical and Physical Section, the chief function of which would be to encourage the presentation and discussion of original papers, and arrange for addresses and discussions on recent advances in these sciences. A Sectional Committee was appointed, with Professor Laby as Chairman and Mr. E. Kidson as Secretary, to carry out the work of the Section. Six meetings have been held at which illustrated lectures on various subjects were delivered by Dr. E. J. Hartung, Squadron-Leader F. S. Barnwell, Mr. W. Stone, Professor T. H. Laby, Mr. E. Kidson, and Dr. J. M. Baldwin, and were attended by large audiences.

A notable event of interest to scientists generally was the meeting in Melbourne and Sydney of the Pan-Pacific Science Congress. This was the most important scientific gathering held in Australia since the meeting of the British Association for the Advancement of Science in 1914. Delegates from all parts of the world attended and represented most branches of science. The Melbourne meeting was held from the 13th August to the 21st August, and was highly successful. Such opportunities of meeting scientific workers from other parts, and exchanging ideas on matters of mutual interest are so rare that the time available proved altogether too short.

A deputation from the Council waited on the Chief Secretary on the 25th July to urge that the Annual Government Grant to the Society be restored to £200, and that a sum of £1000 be made available for carrying out urgent repairs to the buildings, replacing the fence, and binding the publications. It was pointed out that in 1906 the Government Grant was reduced from £200 to £100, and that during and since the war the greatly increased cost of publishing had been a severe strain on the Society's funds. The buildings and fences were in urgent need of repair, and it had not been possible to do any binding for some years.

The Minister expressed his appreciation of the work done by the Society, and thought the Grant should be increased. He undertook to put the matter before the Treasurer and the Cabinet.

On the 27th September, representatives of the Council waited upon the Treasurer, Sir William McPherson, and put the matter before him, with the result that the Government has agreed to restore the Government Grant to £200, to have the buildings thoroughly renovated, and the binding of approximately 800 volumes done by the Government Printer.

Arrangements for the renovation of the buildings are now being made by the Chief Secretary's Department, and an instalment of the binding is in the hands of the binder.

A further attempt was made to have the Society's publications registered for transmission through the post under the book rate of postage, and thus make a noticeable saving in the cost of postage, but without success. A reduction of 50 per cent. on the postage rate for printed matter which came into force in October last, has however, been beneficial.

The Librarian reports the addition of 1,670 volumes and parts during the year. Mr. Kenyon, who has acted as Hon. Librarian for the past three years, found it necessary to resign his position owing to his official duties necessitating his frequent absence from Melbourne. This was received with regret.

Mr. J. A. Kershaw, on the nomination of the Council, was gazetted a Trustee of the Society's grounds in the place of Mr. P. Baracchi, resigned.

Part II. of Volume XXXV. of the Proceedings was issued on the 31st May, and Part I. of Volume XXXVI., on the 13th December. Part II. of the same Volume is now in hand.

HONORARY TREASURER'S REPORT.

The Financial Statement shows the Society to be in a somewhat better position at the beginning of 1924, than twelve months previously. This is due chiefly to the reduced cost of printing of the Proceedings. To obtain this reduction, however, the Council has had to exercise the most rigid economy, and the Proceedings have, in consequence, suffered somewhat in both appearance and volume. In addition, the items for postage and repairs have been reduced, and the Collector dispensed with.

The amount received for subscriptions is less than during the previous year, owing to the large amount of arrears collected in that year. In reality, the position, as regards the number of paying members has improved slightly. The Hon. Treasurer desires, however, to call the attention of members to the slackness with which a large number treat their obligations in regard to payment of subscriptions. This is a position which would be tolerated in few societies. The work of the Hon. Treasurer is quite unnecessarily arduous, and if he is to continue without the services of a Collector, more support must be received from the Society.

It will be obvious from the Statement, that the Society's credit balance has been maintained only by abstaining from much-needed works. It is a great pleasure, therefore to be able to announce that the Victorian State Government has agreed to restore the Grant in aid to £200, to repair the Cottage and Hall, and to bind publications. It behoves the Society, by a display of increased activity, to show its appreciation of this more generous treatment. Furthermore, our library accommodation is becoming increasingly inadequate, while the lecture rooms, besides being too small, are lacking in every convenience for their purpose. Instead of resting content with the present position, therefore, the Society should spare no effort, until, by increasing its membership, and by otherwise securing the support of the public, it becomes possessed of sufficient resources to enable it to undertake the erection of a building adequate to its needs.

Financial Statement for period March 1st, 1923, to January 31st, 1924.

RECEIPTS.

Balance at Current A/c, 1st March, 1923				£213	9	10
Cash in hand ...				3	1	11
Subscriptions—						
Members—Subs. in arrears	£4	4	0			
„ for 1923	148	1	0			
„ in advance	2	2	0			
Associates—						
Subs. in arrears	29	12	0			
„ for 1923	77	14	0			
„ in advance	4	4	0			
Country Members—						
Subs. in arrears	1	1	0			
„ for 1923	13	13	0			
„ in advance	6	6	0			
				286	17	0
Rents—						
Com'wealth Government	£37	10	0			
Field Naturalists' Club...	12	0	0			
				49	10	0
Sales of Publications ...				12	11	6
Victorian State Government Grant in Aid				100	0	0
Donation ...				2	2	0
Exchange on Cheques ...				0	6	0
				£667	18	3

EXPENDITURE.

Publication, Printing and Postage—						
Printing and Publication	£275	19	3			
Postage ...	21	9	2			
				£297	8	5
Maintenance—						
Assistant Secretary ...	£30	0	0			
Assistant Librarian ...	12	0	0			
Caretaker's A/cs. ...	19	13	7			
Rates ...	15	11	4			
Insurance ...	5	1	3			
Sundries — Gas, Electric Light, etc. ...	12	12	2			
Repairs ...	8	2	6			
Petty Cash ...	8	19	4			
				112	0	2
Library ...				4	17	6
				£414	6	1
Credit balance as on 31/1/24—						
Current Account ...				253	8	9
Cash in Hand ...				0	3	5
				£667	18	3

We have examined Pass Books and hereby certify that all amounts entered herein have been paid to the credit of the Society. We have seen receipts for all payments.

EDWARD KIDSON, *Hon. Treas.* 25/2/24

A. E. V. RICHARDSON, } *Hon.*
C. A. LAMBERT, } *Auditors.*

The amount standing to the credit of the Society at the State Government Savings Bank on 1/7/23 was £150 13 10

Subscriptions still owing for 1923 are—Members (2) ...	£4	4	0	
Associates (16) ...	17	17	0	(including one in arrears for 1922 also)
Country Members (2) ...	2	2	0	
	£24	3	0	

Liabilities to Messrs. Ford & Son for printing Proceedings are estimated at £210.

Royal Society of Victoria.

1923.

Patron :

HIS EXCELLENCY THE RIGHT HON. THE EARL OF STRADBROKE, K.C.M.G. C.B, C.V.O., C.B.E.

President :

F. WISEWOULD.

Vice-Presidents :

PROF. T. H. LABY, M.A., Sc.D, F.INST.P.
J. M. BALDWIN, D.Sc.

Hon. Treasurer.

E. KIDSON, O.B.E., M.Sc.

Hon. Librarian :

A. S. KENYON, C.E.

Hon. Secretary :

J. A. KERSHAW.

Council :

E. J. DUNN, F.G.S.
ASSOC. PROF. H. S. SUMMERS, D.Sc.
J. SHEPHARD.
F. CHAPMAN, A.L.S.
D. K. PICKEN, M.A.
PROF. E. W. SKEATS, D.Sc., A.R.C.S., F.G.S.
PROF. W. E. AGAR, F.R.S., M.A., D.Sc.
W. HEBER GREEN, D.Sc.
A. E. V. RICHARDSON, M.A., B.Sc.
H. HERMAN, B.C.E., M.M.E., F.G.S.
PROF. W. A. OSBORNE, M.B., B.CH., D.Sc.
W. GRAY, M.A., B.Sc.

Committees of the Council

House Committee:

THE HON. TREASURER. (CONVENER)
F. WISEWOULD.
J. SHEPHARD.

Printing Committee:

THE PRESIDENT.
THE HON. TREASURER.
THE HON. SECRETARY.
PROF. E. W. SKEATS.

Honorary Auditors:

J. E. GILBERT.
A. E. V. RICHARDSON, M.A., B.Sc.

Honorary Architect:

W. A M. BLACKETT.

Trustees:

PROF. SIR W. BALDWIN SPENCER, K.C.M.G., M A. F.R.S.
F. WISEWOULD.
J. A. KERSHAW.

1923.

LIST OF MEMBERS

WITH THEIR YEAR OF JOINING.

[Members and Associates are requested to send immediate notice of any change of address to the Hon. Secretary.]

PATRON.

His Excellency The Right Hon. The Earl of Stradbroke

HONORARY MEMBERS.

Liversidge, Professor A., LL.D., F.R.S., "Fieldhead," George-road, Coombe Warren, Kingston, Surrey, England.	1892
Verbeek, Dr. R. D. M., Speelmanstraat, 19, s'Gravenhage, Holland.	1886

LIFE MEMBERS.

Fowler, Thos. Walker, M.C.E., "Fernhill," 8 Fitzwilliam-street, Kew.	1879
Gilbert, J. E., 12 Edward-street, Kew, Vic.	1872
Gregory, Prof. J. W., D.Sc., F.R.S., F.G.S., University, Glasgow.	1900
Love, E. F. J., M.A., D.Sc., F.R.A.S., Moreland Grove, Moreland.	1888
Selby, G. W., "Lindisfarne" Scott-grove, E. Malvern.	1889
Smith, W. Howard, "Moreton," Esplanade, St. Kilda ...	1911

ORDINARY MEMBERS.

Agar, Prof. W. E., F.R.S., M.A., D.Sc., University Melbourne.	1920
Austin, E. G., Boeri Yallock, Skipton	1922
Baker, Thomas, Bond-street, Abbotsford	1889
Bale, W. M., F.R.M.S., Walpole-street, Kew	1887
Baldwin, J. M., D.Sc., Observatory, South Yarra	1915
Balfour, Lewis, B.A., M.B., B.S., Burwood-road, Hawthorn.	1892
Baragwanath, W., Geological Survey Dept., Melb. ...	1922
Barrett, A. O., 25 Orrong-road, Armadale	1908

Barrett, Sir J. W., K.B.E., C.M.G., M.D., M.S., Collins-street, Melb. 1910
Brittlebank, C. C., 48 York-street, Caulfield 1898

Casey, R. G., 125 William-street, Melb. 1922
Chapman, F., A.L.S., National Museum, Melb. 1902
Cudmore, F. A., 17 Murphy-street, South Yarra 1920

Davis, Captain John King, "Tasma," Parliament-place, Melbourne. 1920
Dunn, E. J., F.G.S., "Roseneath," Pakington-street, Kew. 1893
Dyason, E. C., B.Sc., B.M.E., Equitable Buildings, Collins-street, Melbourne. 1913

Ewart, Prof. A. J., D.Sc., Ph.D., F.L.S., University, Melb. 1906

Gault, E. L., M.A., M.B., B.S., Collins-street, Melb. 1899
Gilruth, J. A., D.V.Sc., M.R.C.V.S., F.R.S.E., 520 Munro-street, South Yarra. 1909
Gray, Wm., M.A., B.Sc., Presbyterian Ladies' College, East Melb. 1913
Green, W. Heber, D.Sc., University, Melbourne 1896
Grimwade, W. Russell, B.Sc., 420 Flinders-lane, Melb. 1912
Grut, P. De Jersey, F.R.Met.S., 103 Mathoura-road, Toorak. 1869

Harrison, H. C., A.R.C.S., Vic. Barracks, St. Kilda-road, Melb. 1923
Herman, H., D.Sc., B.C.E., M.M.E., F.G.S., "Albany," 8 Redan-street, St. Kilda. 1897
Horne, Dr. G., Lister House, Collins-street, Melbourne 1919

Jannsens, Eugene, 2 Argyle-street, St. Kilda 1923

Kelly, Bowes, Glenferrie-road, Malvern 1919
Kenyon, A. S., C.E., Lower Plenty-road, Heidelberg ... 1901
Kernot, Assoc. Prof., W. N., B.C.E., University, Melbourne. 1906
Kerr, Dr. J. L., F.R.S.E., 29 Blyth-street, Brunswick. 1923
Kershaw, J. A., National Museum, Melb., ... 1900
Kidson, E., O.B.E., M.A., D.Sc., Central Weather Bureau, Melb. 1921

Laby, Prof. T. H., M.A., Sc.D., F.Inst.P., University, Melb. 1915
Laidlaw, W. B.Sc., Botanical Gardens, Domain, S.Y. 1911

Laver, John, Mantell-street, Moonee Ponds	
Lewis, J. M., D.D.Sc., "Whitethorn," Boundary-road, Burwood.	1921
Littlejohn, W. S., M.A., Scotch College, Melb.	1920
Lyle, Prof. Sir Thos. R., M.A., D.Sc., F.R.S., Irving-road, Toorak.	1889
MacKenzie, W. Colin, M.D., B.S., F.R.C.S., 88 Collins-street, Melb.	1910
McPherson, The Hon. Sir William, K.B.E., Copin-grove, St. James's Park, Haw.	1924
Mahony, D. J., M.Sc., "Lister House," Collins-street, Melb.	1904
Mann, S. F., Caramut, Victoria	1922
Masson, Prof. Sir Orme, M.A., D.Sc., F.R.S.E., F.R.S., University, Melb.	1887
Millen, The Hon. J. D., Batman House, 103 William-street, Melb.	1920
Miller, Leo. F., "Moonga," Power-avenue, Malvern ...	1920
Miller, E. Studley, 396 Flinders-lane, Melbourne	1921
Mirfield, C. J., Observatory, South Yarra	1913
Mirfield, Z. A., "The Righi," South Yarra	1923
Mitchell, Prof. J. H., M.A., F.R.S., 52 Prospect Hill-road, Camberwell.	1900
Monash, Lieutenant-General Sir John, G.C.M.G., K.C.B., Doc. Eng., L.L.D., State Electricity Commission, 22 William-street, Melb.	1913
Mullett, H. A., B. Ag., Sc., Dept. of Agriculture, Melb.	1923
Oliver, C. E., M.C.E., Mt. Dandenong North	1878
Osborne, Prof. W. A., M.B., B.Ch., D.Sc., University, Melb.	1910
Owen, W. J., "Gaergybi," 935 Rathdown-street, Nth. Carlton.	1919
Patton, R. T., B.Sc., M.F., Biology School, University, Melbourne.	1922
Payne, Prof. H., M.Inst.C.E., M.I.M.E., University, Melb.	1910
Penfold, Dr. W. J., M.B., "Brampton" Serum Laboratories, Royal Park.	1923
Picken, D. K., M.A., Ormond College, Parkville	1916
Piesse, E. L., 43 Sackville-street, Kew, ...	1921
Pratt, Ambrose, M.A., 376 Flinders-lane, Melb.	1918

Quayle, E. T., B.A., Central Weather Bureau, Melb. 1920

Richardson, A. E. V., M.A., D.Sc., Agricultural Department, Melb. 1912

Rivett, Prof. A. C. D., M.A., D.Sc., University, Melb. 1911

Schlapp, H. H., 31 Queen-street, Melb. 1906

Shephard, John. "Norwood," South-road, Brighton Beach. 1894

Skeats, Prof. E. W., D.Sc., A.R.C.S., F.G.S., University, Melb. 1905

Spencer, Prof. Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., National Museum, Melbourne. 1887

Strevens, John Lloyd, 34 Queen-street, Melbourne ... 1922

Summers, Associate Prof. H. S., D.Sc., University, Melb. 1902

Sweet, Associate Prof. Georgina, D.Sc., University, Carlton. 1906

Thirkell, Geo. Lancelot, B.Sc., 4 Grace-street, Malvern. 1922

Trinder, E. E., "Ruzilma," Orrong-grove, Caulfield 1922

Walcott, R. H., Technological Museum, Melb. 1897

Watt, W. S., Central Weather Bureau, Victoria-street, Melbourne. 1922

Wickens, C.H., F.I.A., F.SS., ... 1923
Commonwealth Statistician, Rialto, Collins-st.

Wisewould, F., "Mona," Pakenham Upper, Victoria 1902

Woodruff, Prof. H. A., M.R.C.S., L.R.C.P., M.R.C.V.S., Veterinary School, University, Melb. 1913

Young, Assoc. Prof. W. J., D.Sc., University, Carlton. 1923

Country Members.

Crawford, W., Gisborne 1920

Dare, J. H., B.Sc., State School 2605, Rathdown-street, Carlton. 1917

Drevermann, A. C., Longerenong Agricultural College, Dooen. 1914

Easton, J. G., Geological Survey, Corryong 1913

Ferguson, E. W., M.B., Ch.M., "Timbrebongie," Gordon-road, Roseville, Sydney, N.S.W. 1913

Harris, W. J., B.A., High School, Echuca 1914
Hart, T. S., M.A., B.C.E., F.G.S., School of Mines, Bairnsdale, Vic. 1894
Hope, G. B., B.M.E., "Carrical," Hermitage-road, Newtown, Geelong, 1918

James, A., B.A., B.Sc., High School, St. Arnaud 1917

Kitson, A. E., F.G.S., C.M.G., C.B.E., 29 Alfred-place, S. Kensington, London, S.W.7, England. 1894
Langford, W. G., M.Sc., B.M.E., Vailala Oilfields, Popo, via Port Moresby, Papua. 1918
Lea, A. M., F.E.S., 241 Young-street, N. Adelaide, S. Australia. 1909

Richards, Prof. H. C., D.Sc., University, Brisbane, Queensland. 1909
Trebilcock, Captain, R. E., M.C., Wellington-street, Kerang. 1921
Turner, A. Jefferis, M.D., F.E.S., Wickham Terrace, Brisbane. 1922

White, R. A., B.Sc., School of Mines, Bendigo, Vict. 1918

Corresponding Members.

Dendy, Professor Arthur, D.Sc., F.R.S., Sec. L.S., King's College, London. 1888

Lucas, A. H. S., M.A., B.Sc., Sydney Grammar School, Sydney, N.S.W. 1895

Merrel, F. P., Rhodesian Museum, Buluwayo, South Africa. 1919

Associates.

Allen, Miss N. C. B., B.Sc., Physics Dept., University, Melb. 1918
Archer, Howard R., B.Sc., Armidale School, Armidale, N.S.W. 1921
Armitage, R. W., M.Sc., F.G.S., F.R.G.S., 95 Foam street, Elwood. 1907
Ashton, H., "The Sun," Castlereagh-street, Sydney, N.S.W. 1911
Bage, Mrs. Edward, "Cranford," Fulton-street, St. Kilda, 1906

Bage, Miss F., M.Sc., Women's College, Kangaroo Point, Brisbane, Queensland. 1906

Baker, F. H., 167 Hoddle-street, Richmond 1911
Barkley, H., Central Weather Bureau, Melb. 1910
Bordeaux, E. F. J., G.M.V.C., B.èsL., Mangalore-street, Flemington. 1913
Breidahl, H., M.Sc., M.B., B.S., 36 Rouse-street, Port Melb. 1911
Brodribb, N. K. S., Cordite Factory, Maribyrnong 1911
Brookes, Leslie R., B.A., High School, Horsham 1922
Bryce, Miss L. M., B.Sc., 22 Victoria-avenue, Canterbury. 1918
Buchanan, G., D.Sc., University, Melb. 1921

Chapple, Rev. E. H., The Manse, Warrigal-road, Oakleigh. 1919
Clinton, H. F., Produce Office, 605 Flinders-street, Melb. 1920
Cook, G. A. M.Sc., B.M., 18 Elphin-grove, Hawthorn 1919
Cookson, Miss I. C., B.Sc., 154 Power-street, Hawthorn 1916
Coulson, A. L., M.Sc., "Finchley," King-street, Elsternwick. 1919
Cousins, Miss M. Y., c/- Mrs. Pearson, Palermo-street Mentone. 1922
Crespin, Miss R., B.A., 67 Studley Park-road, Kew. 1919

Danks, A. T., 391 Bourke-street West, Melb. 1883
Deane, Cedric, 14 Mercer-road, Malvern. 1923
Dunstan, Joseph, "Rockleigh," George-street, E. Melb. 1922

East, L. R., State Rivers and Water Supply Commission, Ouyen 1923
Esserman, N. R., Arsenal Laboratory, Maribyrnong ... 1923

Fenner, C. A., D.Sc., Education Department, Flinders-street, Adelaide, S.A. 1913
Ferguson, W. H., 37 Brinsley-road, E. Camberwell ... 1894
Finney, W. H., 40 Merton-street, Albert Park 1881
Flecker, Dr. H., 4 Collins-street, Melbourne 1922

Gabriel, C. J., 293 Victoria-street, Abbotsford 1908

Hardy, A. D., F.L.S., Forest Department, Melb. 1903
Hartung, Assoc. Prof. E. J., D.Sc., Univ., Carlton ... 1923
Hauser, H. B., B.Sc., Geology School, University, Melb. 1919
Hercus, E. O., M.Sc., Nat. Phil. Dept., Univ., Melb. 1923

Heslop, Dr. G. G., Veterinary School, Parkville, ... 1923
Hoadley, C. A., M.Sc., B.M.E., c/o Richardson Gears, Footscray. 1910
Holmes, W. M., M.A., B.Sc., University, Melb. 1913
Hosking, J. B. O., B.M.E., Harbour Trust, Customs House, Flinders-street, Melbourne. 1922
Howitt, A. M., Department of Mines, Melb. 1910

Jack, A. K., M.Sc., 49 Aroona-road, Caulfield . . 1913
Jona, J. Leon, M.D., B.S., D.Sc., "Hazelmere," Wattle Tree-road, Malvern. 1914
Jones, Miss K. A. Gilman, Church of England Girls' Grammar School, Anderson-street, S. Yarra. 1922
Jutson, J. T., B.Sc., "Oakworth," 2 Austin-avenue, St. Kilda. 1902

Keartland, Miss B., B.Sc., Cramer-street, Preston ... 1919
Keble, R. A., Department of Mines, Melb. 1911
Kerr, Miss Lesley Ruth, St. Monan's, Bacchus Marsh 1922
Kerr, Mrs. Marion Riggall, 29 Blyth-street, Brunswick 1923
Knott, J. V., State Rivers and Water Commission, Ouyen, Victoria. 1923

Lambert, C. A., Bank of N.S.W., Melbourne 1919
Leslie, John Robert, 35 York-street, Prahran 1923
Luher, R. E., B.A., 101 Hickford-street, E. Brunswick 1919
Luly, W. H., Department of Lands, Public Offices, Melb. 1896

McInerney, Miss K., M.Sc., Geology School, University, Melb. 1918
Macdonald, B., Central Weather Bureau, Melbourne 1920
Mackenzie, G., 1 High-street, Prahran 1907
Maclean, C. W., 56 Cole-street Elsternwick 1879
McLennan, Ethel, D.Sc., Botany School, University, Melb. 1915
Melhuish, T. D. A., B.A., Port Pirie, South Australia 1919
Mollison, Miss E., M.Sc., Royal Crescent, Camberwell 1915
Moore, F. E., M.B.E., 4 Mont Albert-road West, East Kew. 1920
Morris, P. F., National Herbarium, S. Yarra 1922

Nicholson, Miss Margaret G., 59 Murray-street, Elsternwick. 1920

Oke, C., 56 Chaucer-street, St. Kilda 1922

Osborne, Miss A., B.Sc., Biology School, University, Melb. 1918

Pern, Dr. Sydney, M.R.C.S., L.R.C.P., 16 Collins-street, Melbourne. 1920

Peterson, Miss K., B.Sc., 56 Berkeley-street, Hawthorn 1919

Pretty, R. B., 99 Primrose-street, Essendon 1922

Raff, Miss J., M.Sc., University, Melb. 1910

Richardson, Sidney C., 21 Whitehall-street, Footscray. 1923

Rosenthal, Newman H., 49 Odessa-street., St. Kilda 1921

Rossiter, Captain A. L., M.Sc., High School, Melb. ... 1913

Scott. T. F., M.A., High School, Hamilton 1917

Sharman, P. J., M.Sc., "Glenalvie," 9 Daphne-street, Canterbury. 1916

Showers, Alan, Geology School, University, Melbourne 1922

Singleton, F. A., M.Sc., Geology School, University, Melb. 1917

Slater, Mrs. Wm., B.Sc., Hamilton, Victoria 1919

Smith, J. A., 15 Collins-place, Melb. 1905

Stickland, John, 433 Brunswick-street, Fitzroy 1922

Stillman, Miss G., "Taiyuan," 3 Grange-road, Kew 1919

Stillwell, F. L., D.Sc., 44 Elphin-grove, Hawthorn ... 1910

Sutton, C. S., M.B., B.S., Rathdown-street, N. Carlton 1908

Thomas, R. G., B.Ag.Sc., State Farm, Rutherglen, Victoria. 1922

Thompson, Mrs. G. R., 26 Fawkner-street, St. Kilda 1922

Thorn, Wm., Mines Department, Melb. 1907

Traill, J. C., B.A., B.C.E., "Myora," Toorak-road, Toorak. 1903

Treloar, H. M., Central Weather Bureau, Melbourne 1922

Trüdinger, W., Gerald-street, Murrumbeena 1918

Williamson, H. B., "The Grange," Corner Waverley-road, East Caulfield. 1919

Wilson, F. E., "Jacana," Darling-road, E. Malvern 1921

Wilson, Major H. W., O.B.E., M.C., C.deG., B.Sc., 630 Inkerman-road, Caulfield. 1923

Woodward, J. H., Queen's Buildings, No. 1 Rathdown-street, Carlton. 1903

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The names of new genera and species are printed in italics.

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